SAN DIEGO BAY COUNCIL

A coalition of San Diego environmental organizations dedicated to protection and restoration of San Diego's coastal water resources.

Environmental Health Coalition San Diego Baykeeper
San Diego Chapter of the Sierra Club San Diego Audubon Society
Surfrider Foundation, San Diego Chapter
Southwest Wetlands Interpretive Association

San Diego Bay Council Comments and Recommendations on Tentative Order No. R9-2004-0154 for Duke Energy South Bay, LLC, South Bay Power Plant

including two supplemental reports:

Notes on South Bay Power Plant 316(a) & (b)
by Pisces Conservation Ltd., July 29, 2004

Recommended Options for Maximum Water Temperature Limits and Minimum Dissolved Oxygen Limits at a Compliance Point for Discharges From the South Bay Power Plant in San Diego Bay, Necessary to Protect Beneficial Uses,
by Dr. Richard Ford, April, 2003

August 18, 2004

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August 18, 2004

Chairman John Minan and Regional Board Members
California Regional Water Quality Control Board
9174 Sky Park Court, Suite 100
San Diego, California 92123-4340

RE: San Diego Bay Council Comments on Tentative Order No. R9-2004-0154 for Duke Energy South Bay, LLC, South Bay Power Plant

Dear Chairman Minan and Boardmembers:

San Diego Bay Council ("Bay Council") and its member organizations: Environmental Health Coalition; San Diego Baykeeper; The Surfrider Foundation, San Diego Chapter; San Diego Audubon Society; Sierra Club, San Diego Chapter; and, Southwest Wetlands Interpretive Association, are writing to submit our comments on Tentative Order R9-2004-0154. As this Board is aware, Bay Council has taken a strong interest in this permit and is pleased that after three long years an Order will finally be before the Board for consideration.

Although there are some portions of the Tentative Order that Bay Council believes are a vast improvement from the previous Tentative Order, we must strongly oppose the adoption of this permit as presently drafted. Instead, we urge the Board to adopt the permit with the amendments described in this letter. In its current form, the draft permit allows the plant to operate for at least another 2-3 years at a level which significantly impacts the San Diego Bay and is inconsistent with existing regulations under the law. In addition, we believe that the South Bay Power Plant ("SBPP") is not in compliance with 316(b) – new and old rules – which further necessitates the adoption of a permit that sets appropriately stringent requirements, as required by law, that protect the beneficial uses of the Bay.

In this letter we will raise our general and specific comments related to the Tentative Order, its Fact Sheet, Duke's studies entitled *South Bay Power Plant Cooling Water System Effects on San Diego Bay, Volume I and II* ("Duke Studies"), and letters by Tetra Tech reviewing the Duke Studies. We have also provided additional technical expert comments and reports to justify our comments and recommendations.

Summary Conclusions

- On-going Bay Degradation Necessitates Adoption of a Permit for SBPP that Will Protect the Bay Now, Not Later.

- Duke Studies Provide Enough Data to Make Determinations that the Plant Does Not Comply with 316(a) and (b) Regulations.

- Duke Studies Demonstrate That the SBPP Results in a Significant Adverse Environmental Impact.

- Duke's Studies Fail to Demonstrate Compliance with 316(a) and (b) (both the old and new regulations).

- SBPP Fails to Comply with 316(a) and (b), Which Further Necessitates the Need to Adopt an Order That Sets Appropriately Stringent and Protective Limits That Will End the Plant's Adverse Environmental Impacts.

- Board Should Adopt an Order that Includes Bay Council's Recommended Dissolved Oxygen and Temperature Limits To Fully Protect Beneficial Uses.

- Duke Has Failed to Appropriately Analyze Potential Best Available Technology Options That Will Minimize And/Or Eliminate the Plant's Adverse Environmental Impact.

- Duke Must Mitigate Current, Past, and Ongoing Damage To Bay Ecosystem.

- Board Should Adopt an Order With a Cease and Desist Order Provision to Ensure Timely and Full Compliance.

Additional Studies and Reports for Consideration

Attached in the Appendix of this letter are two reports. The first report was prepared by Pisces Conservation Ltd. for Bay Council and evaluates the Duke Studies and whether the studies justify a determination of compliance with 316(a) and 316(b) – old and new rules.[1] The second report, entitled *Recommended Options for Maximum Water Temperature Limits and Minimum Dissolved Oxygen Limits at a Compliance Point for Discharges From the South Bay Power Plant in San Diego Bay, Necessary to Protect Beneficial Uses*[2], was prepared by Dr. Richard Ford, a Professor Emeritus of Biology at San Diego State University, that recommends options for maximum water temperature limits and minimum dissolved oxygen limits at a compliance point for discharges from the SBPP in order to protect beneficial uses.

Both reports are meant to provide the Board with more technical information and analysis from experts in their fields. We hope that these reports will help guide Board Members in their decision-making process during the consideration of this Tentative Order, while also offering more technical analysis that may be helpful to Staff.

In addition, for your reference, attached is also a copy of Bay Council's report *Deadly Power*, which outlined our concerns about the SBPP's impact on the environment and public health.[3] The report was submitted to the Regional Board in December of 2001 and made a series of recommendations on what we believe are the appropriate actions to be taken in order to end the SBPP's damaging impacts to the South San Diego Bay.

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[1] R.M.H Seaby, *Notes on South Bay Power Plant (SBPP) 316 (a) & (b),* Pisces Conservation Ltd. IRC House, The Square, Pennington Lymington SO41 8GN, England. Prepared for San Diego Bay Council. (July 29, 2004) ("Pisces Report") The Pisces Report is appendixed to this letter at **Attachment A**.

[2] Richard F. Ford, PhD., Maximum Water Temperature Limits and Minimum Dissolved Oxygen Limits at a Compliance Point for Discharges From the South Bay Power Plant in San Diego Bay, Necessary to Protect Beneficial Uses. Prepared for San Diego Bay Council. (April 4, 2003) ("Ford DO Study") This report is attached to this letter as **Attachment B**.

[3] *Deadly Power: A case for eliminating the impacts of the South Bay Power Plant on San Diego Bay and ensuring better environmental options for the San Diego/Tijuana region.* Prepared by the San Diego Bay Council. (December 3, 2001) This report is appendixed to this letter at **Attachment C**.

General Comments on Tentative Order

Bay Council is encouraged to see that this order represents a vast improvement over the 2001 Tentative Order. We strongly support the Board's findings that the SBPP is not in compliance with 316(a) and new 316(b) regulations, the moving of monitoring stations for discharges from S1 to S2, and requiring CTR effluent limitations for copper and other toxic metals. With these new additions, we believe this Tentative Order is one step closer to ensuring the protection of our Bay. However, there are a number of significant weaknesses with this Tentative Order that we believe, if fixed, would present an Order that we could fully support. This letter outlines, generally and specifically, our comments, and recommendations that we believe would significantly strengthen the Tentative Order.

A. On-going Bay Degradation Necessitates Adoption of a Permit for SBPP that Will Protect the Bay Now, Not Later.

For over 40 years, the South Bay Power Plant ("SBPP") has impacted the Bay's ecosystem with thermal and chemical pollution and by killing a wide range of juvenile, larval, and adult organisms in its cooling system. The damage to the marine life in San Diego Bay by the SBPP has been constant, significant, and unmitigated. The cumulative impact has been devastating. The Bay's current degraded and altered condition is now so long-standing that it is considered the "base-line" for South Bay. It is time for a change for South San Diego Bay.

With this permit renewal, there is a significant opportunity for the Regional Board to send a clear message that this operation needs to either re-invent itself or operate in a manner that no longer impacts the Bay. The requirements recommended for the permit in this letter are the means to bring the power plant into compliance with regulations of the law and to partially mitigate the damages of the plant to allow the plant to continue to operate until a new project is determined.

In taking this action, however, the Regional Board needs to be vigilant. Duke's recent settlement for manipulation of the market and earlier attempts to seek waivers that would allow more damage to the Bay mean they are not to be "taken on faith." Rather, they need to be given clear, stringent, and direct requirements to all aspects of monitoring, compliance, and operations.

B. Duke's Studies Fail to Demonstrate Compliance with 316(a) and (b)

Bay Council hired Pisces Conservation Ltd. ("Pisces") to review the Duke Studies and to evaluate whether the studies justify a finding for compliance with CWA 316(a) and (b) requirements.[4] Pisces is an internationally recognized consultancy firm with over 30 years of experience on the effects of power plants on aquatic environments. In particular, Pisces has developed a reputation as the international expert on the impacts of entrainment and impingement, as well as thermal discharges, on water quality and marine life. In addition, Pisces was the primary expert witness for Hudson Riverkeeper's lawsuit against U.S. Environmental Protection Agency ("EPA") that led to the promulgation of new, stricter 316(b) regulations. EPA has recognized Pisces as an expert on 316(b) issues, and recently featured Pisces as a presenter at the EPA 316(b) Symposium on Technologies for Protecting Aquatic Organisms from Cooling Water Intake Structures.

Based on Pisces's review of the Duke Studies and other publicly available documents, Pisces has concluded that SBPP does not comply with 316(a) or (b) – both the old and new versions – regulations. Their analysis is discussed in further detail below.

1. 316(a)

Bay Council agrees with the Tentative Order's conclusion that the SBPP is not in compliance with 316(a) requirements.[5] In addition, we agree with the conclusions reached by both Tetra Tech and Pisces that the Duke Studies do not support a finding of compliance under 316(a) due to issues related to dissolved oxygen, loss of eelgrass habitat, and lower diversity or loss of species of benthic invertebrates.[6] We are also pleased to see that the discharge temperature compliance point has been moved from S1 to S2. However, as is demonstrated below, Bay Council believes that the Board should adopt more stringent and protective limits for dissolved oxygen and temperature.

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[4] *See* Pisces Report.

[5] *See* Tentative Order ("TO") at 3.

[6] Ibid.; Tetra Tech, Inc. letter to Regional Board Staff evaluating Duke Studies and recommending against a determination of compliance with 316(a) regulations, page 1 (May 31, 2004); and Pisces Report at 3.

2. 316(b) – old and new regulations

As the Tentative Order is now written, Bay Council strongly opposes allowing the SBPP to essentially operate "as-is" for another 2-3 years until Duke completes more studies. As stated earlier, the South Bay has already significantly impacted the Bay for over 40 years. Now that the Board has an opportunity to act, it must take swift action to change the status quo and not to allow business as usual. The time for studies is over and the time to act is now.

The Tentative Order finds that the SBPP is in compliance with old 316(b) regulations, but not with the recently promulgated Phase II 316(b) regulations for existing facilities.[7] To address the non-compliance with new 316(b) regulations, the Tentative Order requires Duke to perform a Comprehensive Demonstration Study and to meet one of the five compliance alternatives listed in section 125.94(a) of the new rule.[8]

Bay Council, relying on the Pisces and Tetra Tech Reports, believes that the Duke Studies provide enough data and information to reach a finding of non-compliance with old 316(b) regulations (discussed in more detail below). Furthermore, Bay Council agrees with the Tentative Order's finding that Duke is not in compliance with new 316(b) Phase II regulations as well.

C. Duke Studies Fail to Demonstrate Compliance with Old 316(b) Rules

After reviewing Duke's studies, the entrainment data presented in it, and other relevant data, Pisces Conservation concluded that the SBPP acts as a suppressor on the ecosystem, continually removing and killing a wide variety of organisms, and therefore results in an Adverse Environmental Impact, as defined in the old 316(b) regulations.[9] U.S. EPA defines Adverse Environmental Impact as follows:[10]

> Adverse aquatic environmental impacts occur whenever there will be entrainment or impingement damage as a result of the

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[7] *See* TO at 3.
[8] *Ibid* at 3.
[9] See Pisces Report at 5, 6, and 16.
[10] Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the Aquatic Environment: Section 316(b), Public Law 92-500, U.S. EPA, 1977.

> operation of a specific cooling water intake structure. The critical question is the magnitude of any adverse impact.
>
> The magnitude of an adverse impact should be estimated both in terms of short-term and long-term impact with reference to the following factors:
>
> (1) Absolute damage (# of fish impinged or percentage of larvae entrained on a monthly or yearly basis);
>
> (2) Percentage damage (% of fish or larvae in existing populations which will be impinged or entrained, respectively);
>
> (3) Absolute and percentage damage to any endangered species;
>
> (4) Absolute and percentage damage to any critical aquatic organism;
>
> (5) Absolute and percentage damage to commercially valuable and/or sport fisheries yield; or
>
> (6) Whether the impact would endanger (jeopardize) the protection and propagation of a balanced population of shellfish and fish in and on the body of water from which the cooling water is withdrawn (long term impact).

Both the Duke Studies and Pisces point out that there was a significant percentage loss of eelgrass, a critical aquatic organism covered in section 4 above, and the loss of a large proportion of species of fish and larvae, covered in section 2 above.[11]

D. SBPP Entrainment and Impingement Data Justifies Finding for Adverse Environmental Impact

Pisces stated because the SBPP intakes tend to kill and result in absolute damage to a disproportionately large numbers of small animals and juveniles, they tend to impoverish the standing crop at lower trophic levels towards the base of the ecosystem, thus resulting in the ecosystem in the vicinity of the intake gradually distorting under this unnatural mortality.[12] They point out that the South San Diego Bay was a restricted water body where the plant could utilize the total volume of the water in the South Bay every 60 days, thus allowing the potential for the impingement and entrainment mortality to reduce the

[11] *See* Pisces Report at 6.
[12] *Ibid.* at 16.

local population by a significant amount.[13] To support that assertion, they conclude that based on the entrainment data in the Duke studies, the number of fish entrained by the SBPP represent a considerable part of the local population, and that it is a well-established scientific principle that such losses can have a long-term impact on populations, even of short-lived, high fecundity species such as gobies. Pisces states:[14]

> It is clear that the entrainment and impingement mortality rates observed would not allow isolated populations within San Diego Bay to maintain their size. The power station is causing the Bay to act as a trap that kills animals recruited from the ocean beyond. While many of the animals killed are derived from populations that extend beyond the bay, it should be noted that many of the fish killed by the cooling water system are typical members of the San Diego Bay community. Thus it is quite possible that the present cooling water system has reduced the size of the local fish and crustacean population by a significant amount.

E. Significant Eelgrass Loss in South Bay Justifies Finding of Adverse Environmental Impact

The Tentative Order states that the operation of SBPP, if operating at full capacity, would preclude eelgrass, a critical aquatic organism, from approximately 104 acres of South San Diego Bay, and at the mean summer 2003 operating conditions, would preclude eelgrass from approximately 71 acres of the south San Diego Bay.[15] Pisces points out that these losses would represent 10% of the eelgrass habitat in the entire bay (a significant percentage of damage), and result in significant impacts on the community structure as a whole.[16] Pisces attributes this loss of eelgrass to the thermal, chemical, and entrainment/impingement impacts of the SBPP.

Through an exhaustive analysis supported by scientific studies and reports on eelgrass from around the world, Pisces concludes:[17]

> Eelgrass is a habitat-modifying species. As such, it has a very significant effect on the habitat and community of

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[13] *Ibid.*
[14] *Ibid.*
[15] See Duke Studies at 3.2-3 – 3.2-4.
[16] See Pisces Report at 9.
[17] *Ibid.* at 13.

> the Bay. It creates organic material that in turn supports a complex food web of detritivores and consumers. It is used for shelter by many fish species, and is an important food and habitat for birds. It is affected by temperature and suspended solids; large areas have been lost due to the operation of SBPP. Other areas may be growing less well than they would without the effect of the power plant. The ramifications of this loss are complex and difficult to quantify.

F. High Mortality Rates for Larval Fish Due to Entrainment and Impingement Justify a Finding of Adverse Environmental Impact

Duke's entrainment data demonstrated that the SBPP results in a significant loss of production for species, including a large percentage of larval species, either by removal from the system or by organisms living and growing sub-optimally. Pisces concludes that as much as 27% of some larval fish are currently entrained by the SBPP and that impacts of this magnitude are unsustainable.[18] However, the Duke Studies discount these losses under a theory of surplus production and, as such, conclude that the losses have no effect on the environment, thus the SBPP does not violate 316(b) regulations. The concept of surplus production is based on the view that the entrained organisms, and particularly larval fish, were in most cases never going to become adults and that their loss is therefore of no significance and explained away as natural mortality.

Pisces concludes that the theory of surplus production in this case is erroneously based on principles developed in agricultural and domestic scenarios and have no relevance in nature where natural variability plays a central part in determining populations.[19] They cite a number of scientific studies that support its conclusion. In addition, Pisces argues that the loss of larval species due to the SBPP cannot be evaluated on its own, because it also denies other organisms this food resource.

Bay Council believes that Pisces raises significant doubts regarding Duke's explanation for the high mortality rates from SBPP's intake system. The Board should reevaluate the impact of the SBPP's cooling system on the high mortality rates for fish and larval species, in particular, while considering the issues raised by Pisces.

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[18] *Ibid.* at 3.
[19] *Ibid*. at 19 to 22.

G. Duke Studies Do Not Adequately Assess Indirect Adverse Environmental Impacts to Commercially Valuable Fish and Impacts to the Marine Ecosystem

Pisces demonstrates that the Duke studies on entrainment and impingement erroneously focused primarily on fish they designated to have commercial value (i.e. halibut), but failed to consider other species lost with commercial value or those whose loss directly or indirectly impacts fish of commercial value. They state: *"Only a small fraction of the life forms present in a water body are normally given a monetary value (approximately 1 in every 100 species). Yet almost all the species present in the water column or living on the river or seabed in the vicinity of the outfall will be impacted by a direct cooled power plant. Most are not fished or sold in any form and are not of immediate value as tourist features…the question is how should we consider the worth of the other 99%, many which are small or even microscopic."*[20]

Pisces point out that due to the interdependence of all species, economically important species are dependent upon the existence of many other species either directly because they are their food or indirectly because they help to create some aspect of the habitat that is essential for their existence.[21]

Pisces points to examples of clear dependence between two species such that a dependent species that has an economic value cannot exist without another supporting species. They recommend an approach the Board could take, which involves assigning the supporting species a value as a resource base for the economically important species, in order to fully assess the overall value of the resources lost in terms of its food value to commercially valuable species,[22] but points out that this approach, although more comprehensive, still does not represent the full value of species lost by SBPP's operations. These unquantifiable losses include:[23]

- Loss of recycling efficiency and the loss of nutrients and materials to the local ecosystem;

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[20] *Ibid.* at 16 and 17.
[21] *Ibid.* at 17 and 18.
[22] *Ibid.* at 17.
[23] *Ibid.* at 18.

- Power plant mortality will tend to favor short-lived species at the expense of long-lived forms;
- Damage and alteration of the ecosystem by the plant allows for the invasion of unwelcome aliens and predatory species;
- Damage to the ecosystems may increase the risk of development of organisms dangerous to human health;
- Loss of the ecosystem's service of demobilizing and detoxifying chemical waste products in the water;
- Loss of the ecosystem's service of the stabilization and accumulation of sediments; and
- Loss of support to the terrestrial ecosystem.

Bay Council believes that the Board should strongly consider the number and percentage loss of other species that may not have a direct commercial value in the market, but provide the crucial support system (either as food or as a crucial part of their habitat) for sustaining healthy populations of commercially valuable fish.

H. Duke Studies Do Not Adequately Assess Adverse Environmental Impact to Benthos in the Bay

A healthy benthos is an indication of a healthy bay. A stressed benthos, however, is an indication of an unhealthy bay. The Duke studies failed to examine whether the health of benthos around the SBPP was impacting habitat in the vicinity of the plant. However, Pisces finds that the SBPP has impacted the benthos in the Bay, that its impacts to the benthos are measurable, and that its impacts are likely to be affecting the production of the habitat in the vicinity of the plant.

Pisces points to data showing a high biomass of nematodes and oligochaetes in the benthic samples around the outfall of the plant to conclude that the benthos is highly stressed around the SBPP. They argue that it is generally known that low diversity habitats with high abundance of pollution-tolerant species such as nematodes and oligochaetes are a sign of a disturbed or polluted environment. In addition, they point to data showing an increased diversity (i.e. the relative importance of the worms decreases) with distance down the discharge channel. Pisces attributes the dominance of nematodes and oligochaetes in the discharge channel to organic enrichment and subsequent low oxygen (due to high levels of bacterial respiration).[24]

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[24] *Ibid.*

The Board should fully consider the SBPP's impact on the benthos of the South Bay, while considering the issues raised by Pisces. To fully assess the impact, Board should require additional seasonal, quarterly benthic invertebrate sampling in the MRP (for more details, please see "Monitoring and Reporting – Specific Comments," #13, below).

I. SBPP Fails EPA Steps for Ensuring Compliance with 316(b) When a Finding of an Adverse Environmental Impact is Made

If there is an Adverse Environmental Impact, 316(b) requires the following steps to be completed in order to ensure compliance:[25]

- *The first step should be to consider whether the adverse impact will be minimized by the modification of the existing screening systems.*

- *The second step should be to consider whether the adverse impact will be minimized by increasing the size of the intake to decrease high approach velocities.*

- *The third step should be to consider whether to abandon the existing intake and to replace it with a new intake at a different location and to incorporate an appropriate design in order to minimize adverse environmental impact.*

- *Finally, If the above technologies would not minimize adverse environmental impact, consideration should be given to the reduction of intake capacity which may necessitate installation of a closed cycle cooling system with appropriate design modifications as necessary.*

Pisces concluded that SBPP fails on most of these steps. First, Pisces shows that the existing screening system is the only feasible option considering the large volumes of water passing through the system.[26] Pisces also concludes that fine mesh and wedgewire screens are probably impractical with the SBPP volume and in this situation.[27] Finally, Pisces points out that the fact that the screens are not rotated

[25] Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the Aquatic Environment: Section 316(b), Public Law 92-500, U.S. EPA, 1977.
[26] *See* Pisces Report at 6
[27] Ibid.

continuously and are open to predation means that the survival probability of any impinged fish returned to the discharge canal will be lower than is technically possible.[28]

Pisces recommends that intake velocity and position of the intake are fundamental design parameters of the system and could only be altered by using less cooling water or a reengineering of the intake configuration to, for example, one that is closed-cycle cooling.

Tetra Tech, a consultant hired by the Regional Board to review the Duke Studies and submit a recommendation on whether SBPP is in compliance with 316(a) and (b), also raises strong concerns as to whether the SBPP is minimizing impingement and entrainment impacts. Tetra Tech states:

> "It is disingenuous [for Duke] to state ' SBPP employs design features to minimize entrainment and impingement' without offering any evidence in support of such a claim. Based on initial reviews, there are no evident features currently employed that can be regarded as sufficient for minimizing entrainment. Also the 'fish return system' is something of a misnomer. Any fish that are returned alive off the screens will be subject to predation and substantial physical stress before it us actually returned to the discharge canal."[29]

They even go as far as to say that these problems "raise concerns over the effectiveness of reducing the mortality of impinged organisms" at the SBPP.[30] Tetra Tech also points out other failings:[31]

- Lack of collection or conveyance of the screen panels
- Lack of low pressure fish spray
- Lack of supplemental flow in fish return trough
- Open fish return pipe allows for predation
- Lack of a "smooth ride" to the discharge (corroded iron pipe, sharp return to discharge point)

Bay Council is seriously concerned that Duke has not taken all the available steps necessary to minimize the impact of the plant, to comply with the requirements for 316(b), and to fully divulge the impacts of entrainment and impingement We believe that reduction of

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[28] Ibid.
[29] Tetra Tech, Inc. letter to Regional Board Staff, page 2 (April 26, 2004). Tetra Tech was hired by the Regional Board to evaluate the Duke Studies and to make a recommendation as to whether the SBPP is in compliance with 316(a) and (b).
[30] Ibid.
[31] Tetra Tech, Inc. letter to Regional Board Staff, page 6 (April 21, 2004).

cooling water used or a fundamental change in the intake configuration, are the only ways that Duke can comply with these requirements. In addition, we believe that Duke has failed to sufficiently assess alternative technologies (see below) that may be available. It is clear that unless the Board takes action, Duke will continue to take a "do nothing" approach as far as re-inventing the manner in which it operates. As a result, we request that the Board take a strong stance on requiring that Duke install new Best Available Technology (BAT) on SBPP to significantly reduce mortality of impinged and entrained organisms.

J. Duke's Technology Assessment is Insufficient to Comply With 316(b)

Bay Council agrees with Tetra Tech's conclusions regarding Duke's Technology Assessment for compliance with new 316(b). Tetra Tech states, "There is an over-reliance on the assumption that the plant will cease operations in 2009 or shortly thereafter, thereby making the cost of all compliance technologies seemingly out of reach." [32]

Although SBPP's lease to operate ends in 2009, SBPP is currently designated a Reliability Must-Run ("RMR") by the California Independent Operator System ("Cal ISO") at its full MW potential. The lease specifically states that if RMR status is still on SBPP at the time the lease ends, the plant will continue to be operated by Duke indefinitely until RMR status is removed. With the lack of new power plants being constructed in the San Diego region and with the continuing growth of energy demand in the region, it is absolutely conceivable that the SBPP may continue to operate well-beyond 2009. As such, Duke must assess the economic feasibility of technology options on a short- and long-term range, instead of assuming the plant's closure in 2009, which precludes any substantial technological upgrades or retrofits. The Duke Studies fail to demonstrate any in-depth feasibility analysis beyond 2009.

Bay Council requests that the Board make a finding in the Fact Sheet that states that although the SBPP lease may end in 2009, due to RMR status, there is a realistic possibility that the plant may operate beyond that date.

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[32] Ibid.

K. Regional Board Should Include Dissolved Oxygen & Temperature Limits That Are Protective of the Beneficial Uses in the Permit.

Bay Council recommends significant changes to the Tentative Order effluent temperature limitation and dissolved oxygen ("DO") in the receiving waters. These recommendations are based on the report prepared for San Diego Bay Council by Richard F. Ford Ph.D. and entitled *Recommended Options for Maximum Water Temperature Limits and Minimum Dissolved Oxygen Limits at a Compliance Point for Discharges From the South Bay Power Plant in San Diego Bay, Necessary to Protect Beneficial Uses.*[33] Dr. Ford bases his recommendations not only on several of the CWA Section 316(a) studies cited in the Tentative Order Fact Sheet, but also on information from species-specific laboratory and field studies concerning temperature and DO tolerances of marine invertebrates and fish species that inhabit the inner Bay.

Dr. Ford provided several options for limits on DO and temperature that would allow the SBPP to protect beneficial uses. Bay Council has selected Dr. Ford's most stringent option for temperature and DO criteria in the receiving waters, as it is the most protective of beneficial uses option. The criteria are set for each month of the year rather than one set for the entire year. The data were determined from full six calendar years 1997 -2002 measured and reported to the San Diego RWQCB by MEC Analytical Systems, Inc., Carlsbad, California. The measurements were taken at Station N2. Water temperature measurements were made at 2-foot depth intervals in the water column from near surface to just above the bottom for each date. DO concentration data include daytime measurements made near the surface and just above the bottom on each date. All data were pooled for each month. Table 1 below lists the monthly maximum discharge temperature as measured at the compliance point S2* and the receiving water minimum dissolved oxygen.

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[33] *See* Ford DO Study, Attachment B

Table 1

Maximum Cooling Water Discharge Temperature and
Minimum Receiving Water Dissolved Oxygen

Month	Max. Temp. Deg F	Min. DO mg/L
January	**62**	**8.0**
February	**62**	**7.6**
March	**67**	**7.5**
April	**68**	**6.4**
May	**72**	**6.5**
June	**76**	**6.7**
July	**78**	**6.5**
August	**80**	**6.2**
September	**78**	**5.0**
October	**73**	**5.9**
November	**68**	**7.1**
December	**67**	**7.0**

* In should be noted that compliance point used in the Ford report has now been revised to S2.

In addition to specifying the minimum dissolved oxygen, Dr. Ford states that from an ecological standpoint, the Basin Plan water quality objectives for dissolved oxygen are entirely appropriate for the inner San Diego Bay. Furthermore, it is the opinion of Bay Council that the Basin Plan DO criteria should apply (please see a more thorough legal analysis in section M). The Basin Plan requires that dissolved oxygen levels shall not be less than 5.0 mg/L in inland surface waters with designated marine habitat (MAR). The annual mean dissolved oxygen concentration shall not be less than 7 mg/L more than 10% of the time.

In order to assess the impact of the cooling water effluent, we concur with Dr. Ford's recommendation that a seasonal (quarterly) marine ecological monitoring program be conducted. This should include taking and analyzing the invertebrate infauna, employing a minimum of five replicate, 0.1 sq. m Van Veen grab samples at a series of stations within and outside the extent of the thermal plume including Stations F3 and N2. The invertebrate infauna samples shall be analyzed using the methods of the Ford and Chambers 1972-73 study[34] and summarized per the E.A. Engineering, Science, and Technology 1995 report [35].

L. Dr. Ford's Report Provides Additional Insight into SBPP Adverse Environmental Impacts Caused by Effluent with Elevated Temperature and Reduced Dissolved Oxygen

Dr Ford relied on species-specific studies that are summarized here as they provide new information to support our recommendations regarding DO and temperature limits. These studies combined laboratory and field data conducted to determine temperature tolerances and preferences of four major species of larger marine animals that are important members of the bottom communities in South San Diego Bay. These are the suspension feeding bivalve mollusks *Solen rosaceus* (rosy razor or pencil clam) and *Tagelus californianus* (California jackknife clam), the filter feeding bivalve *Chione fluctifraga* (smooth cockle), and *Paralichthys californicus* (California halibut). Studies on the rosy razor and jackknife clams found the following:

- Population densities of the rosy razor clam and jackknife clam were lower than in the control station located beyond the thermal plume.
- The jackknife clams in the discharge channel had higher growth rates but smaller size than those of individuals living beyond the discharge channel, indicating adverse effects of elevated temperature.
- Annual mortality rates of the rosy razor clam were higher within the inner thermal plume.
- Life history traits of the rosy razor and jackknife clams differed between the control and thermal plume station locations because of elevated temperature. They displayed variable reproductive effort, fewer young, and shorter life span compared to those in the control location.

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[34] Ford and Chambers, *Thermal Distribution and Biological Studies for the South Bay Power Plant*, May 1973

[35] E.A. Engineering, Science, and Technology. (EAEST*), South Bay Power Plant Receiving Water Monitoring Program with Emphasis on the Benthic Invertebrate Community (1977-1994).* 1995

Another study on the effects of elevated temperature on the smooth cockle revealed similar results:

- Accelerated growth rates in both summer and winter. Accelerated growth rate in winter was unusual as this is the period when growth rate is reduced in the natural population. This clearly indicates an adverse effect.
- Long-term mortality rates were significantly higher and may include basic metabolic disturbance, as indicated by loss of tissue weight.
- Laboratory tests observed decreased burrowing rate compared to normal activity patterns. During elevated temperature conditions, the decreased burrowing activity in the discharge channel would result in increased predation. Observers noted numerous fresh shell fragments in the sediment and fecal material from unidentified shore birds on the sediment surface in mudflats bordering the discharge channel. They found less shell fragments on the Sweetwater mudflats that are located well beyond the thermal influence of the power plant suggesting a lower level of predation.

Laboratory studies on the water temperature preference of the California halibut revealed that about 50% of juveniles displayed an avoidance behavior to elevated temperatures. Dr. Ford notes that this behavior may be of ecological concern as it reduces their food foraging area. Furthermore, the absence of their predatory feeding activity within the elevated temperature areas may cause unnatural changes in the prey population within this region.

Dr. Ford concluded that the laboratory and field studies of these four important species help to explain the results of the general ecological field monitoring studied of 1968-1994. These specific studies have identified more subtle and important adverse effects on growth, reproduction, burrowing activity and behavioral responses of the test species when exposed to high temperatures in different locations of the inner and outer thermal plume. He states that results of these important species-specific studies must be considered in establishing the temperature and dissolved oxygen at the compliance point that truly protect the beneficial uses of inner San Diego Bay.

M. Tentative Order Improperly Concludes that Dissolved Oxygen Requirements of the Basin Plan Do Not Apply to SBPP

The Tentative Order states that "enclosed bays such as San Diego Bay may or may not fall under the classification of 'inland surface waters with designated marine beneficial uses' as implied in the Basin Plan."[36] As the Tentative Order points out, if the San Diego Bay were designated as an inland surface water, the Basin Plan's water quality objectives for DO would apply to the SBPP, meaning the DO levels could not be less than 5.0mg/l, and the annual mean DO concentration limits could not be less than 7mg/l more than 10% of the time.

Bay Council believes no ambiguity exists in the Basin Plan as to whether the water quality objectives for DO apply to the San Diego Bay. The Basin Plan clearly states that the following water quality objectives, in which DO water quality objectives are listed, apply to "all inland surface waters, enclosed bays, and coastal lagoons and ground waters."[37] However, the Basin Plan defines "Coastal Waters" as ocean waters, enclosed bays, and estuaries.[38] So, it is clear that the Basin Plan intended to require that not only inland surface waters, but also some Coastal Waters, including enclosed bays, meet water quality objectives for DO. The San Diego Bay is widely-considered to be an enclosed bay. As a point of reference, the Porter-Cologne Act defines "Enclosed Bays" as all bays where the narrowest distance between the headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay.[39] Porter-Cologne goes on to say that "Enclosed bays" include, but not limited to, Humbolt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles-Long Beach Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.[40]

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[36] See Tentative Order, Fact Sheet at 33.
[37] Water Quality Control Plan for the San Diego Basin ("Basin Plan") (Adopted on September 8, 1994), pgs. 3-5 and 3-8.
[38] See Basin Plan at 2-9.
[39] Porter-Cologne Act, Chapter 5.6 Bay Protection and Toxic Cleanup, §13391.5
[40] Ibid.

Tentative Order – Specific Comments

1. Order 96-05 cites intake pump nameplate flow capacities. However, the Tentative Order does not. Using the cited 136,800 gpm (197 MGD) rating for Unit 4 does not concur with the 190.0 MGD for Unit 4 shown on Attachment 1 of the Tentative Order. Furthermore, the Tentative Order no longer provides the intake flow capacities in the Fact Sheet. **Bay Council requests that the Tentative Order explain these differences.**

2. Page 6, Prohibition #5. The waiver of the prohibition of naturally-occurring material (vegetation, dead animals or fish) that is drawn into the once-through cooling water cooling system raises several concerns. This material in the return trough attracts birds and fishes and other aquatic life to the discharge channel modifies the natural feeding behavior and potentially the distribution and abundance of the species. As Tetra Tech and Pisces have pointed out (mentioned above), predation is a significant problem to the optimal functioning of the "fish return system" and leads to higher mortality rates. **Bay Council requests that the Prohibition of naturally occurring material that is drawn into the once-through cooling system be reinstated in the Tentative Order.**

3. Page 6, Prohibition #9. Bay Council is extremely concerned about the impact of chlorine in the discharge plume of SBPP. It is concluded in the Duke studies that the phytoplankton community will not be impacted by contact with the effluent plume because of the temperature tolerance of the species present. No consideration, however, is given to other properties of the plume, in particular the presence of chlorine biocide. Residual chlorine in the discharge will be allowed up to the permitted concentration of 0.2 mg/l (milligrams per liter). As Pisces points out, studies demonstrate that photosynthetic activity is considerably reduced at residual chlorine levels well below 0.2 mg/l and conclude that bacterial activity is suppressed at chlorine levels below detection levels.[41] While chlorination will only be intermittent (not discharged from any single generating unit for more than two hours per day), there will be periods when the effluent will impact the local phytoplankton community. Pisces states that larvae of oysters are also known

[41] See Pisces Report at 8-9.

to be vulnerable to low levels of chlorine.[42] Studies have also demonstrated that chlorine concentrations of 0.05 mg/l caused about 50% of Pacific oyster, *Crassostrea gigas*, larvae to develop abnormally.[43] Furthermore, larvae of American oysters have a 48h LC50 (the concentration at which 50% of the animals die) of less than 0.005 mg/l.[44] In 40 CFR Part 423.13, it states that the total residual chlorine[45] may not be discharged from any unit for more than two hours in any one day and not more than one unit in any plant may discharge total residual chlorine at any one time unless the utility can demonstrate to the NPDES permit issuing authority that the units in a particular location cannot operate at or below this level of chlorination. Prohibition #9 limits the discharge duration to 2 hours, but then states that "simultaneous multi- unit chlorination is permitted." Given descriptions in the Fact Sheet, our conclusion is that the 2-hour limit is violated. The total chlorination duration per cycle for all four units is 40 minutes times 4 for a total duration of 160 minutes or 2.67 hours.

It is clear that chlorine, even at low levels of detection, have an adverse impact on marine life. **As a result, Bay Council is concerned that multi-unit chlorination is permitted and requests that the Tentative Order justify why simultaneous multi-unit chlorination is permitted under 40 CFR 423.**

4. Page 7 Tentative Order. Paragraph B. Effluent Limitations, 1(a) Cooling Water Discharge. **Board should require that the temperature of the cooling water requirement be replaced by monthly maximum temperatures as shown below:[46]**

[42] Ibid.
[43] Ibid.
[44] Ibid.
[45] The text of the Tentative Order uses chlorine residual and residual chlorine interchangeably. We use residual chlorine to be consistent with 40 CFR.
[46] Justification for these numbers appears in this letter in Section K, above.

Month	Max. Temp. Deg F
January	**62**
February	**62**
March	**67**
April	**68**
May	**72**
June	**76**
July	**78**
August	**80**
September	**78**
October	**73**
November	**68**
December	**67**

5. Paragraph B, Effluent Limitation, 1(d). Bay Council does not concur with the method used to determine the total residual chlorine for reasons stated in the comments on the Fact Sheet**. Board should adopt the SWRCB Ocean Plan method for setting the total residual chlorine limit to be used, as it is more protective of the aquatic life.**

6. Paragraph C, Correct to add maximum intake flow. Cooling Water Intake Structure Specification fails to specify maximum daily intake flow. The Fact sheet describes pump characteristics of the cooling system but these are not enforceable.

7. Tentative Order Receiving Water Limitations. **Board should require that new requirements for dissolved oxygen be added.**[47]

   a. **Set minimum monthly dissolved oxygen requirements as shown**:

[47] Justification for these numbers appears in this letter in Section K, above.

Month	**Min. DO mg/L**
January	**8.0**
February	**7.6**
March	**7.5**
April	**6.4**
May	**6.5**
June	**6.7**
July	**6.5**
August	**6.2**
September	**5.0**
October	**5.9**
November	**7.1**
December	**7.0**

b. **Apply the Basin Plan water quality objective for dissolved oxygen:**[48]

> The dissolved oxygen levels shall not be less than 5.0 mg/L. The annual mean dissolved oxygen concentration shall not be less than 7 mg/L more than 10% of the time.

8. Page 11, Paragraph D, Receiving Water Limitations section 2. The total residual chlorine limitation is specified by the same regression equation used to limit the effluent residual chlorine. While this is keeping with the requirement not to allow mixing zones, it allows residual chlorine at monitoring stations beyond the immediate property line that are well in excess of the EPA national water quality criteria for residual chlorine. As noted previously the ambient levels of residual chlorine reported in the draft Vol. I of the May 2004 Duke 316(a) report Figure 2.8-2 at the intake and discharge channels average range from 20 to 42 parts per billon (or 0.020 to 0.042 mg/l) with maximum values of about 62 ppb at both locations.

   The Board should require that the State Ocean Plan be used for the total residual chlorine limitation for intermittent discharges. Because residual chlorine is discharged intermittently, the receiving water limits will depend on the number of chlorination cycles and value of the total residual chlorine computed for each cycle during the period of

[48] Justification for applying the Basin Plan limits appears in this letter in Section M, above.

the monitoring frequency (weekly in this case). We recommend that the average and maximum of computed from this data set be used for the measured receiving water limitations.

Fact Sheet – Specific Comments

1. Page 2. Fact sheet, Monitoring Requirement, *Significant Changes*, Item f.

   It states that the bar rack approach velocity monitoring has been eliminated. The purpose of the old permit was to assure that the approach velocity be within the traveling screen specifications. Bay Council believes that the velocity should be measured monthly at lowest predicted tide for the month. The reason is to obtain velocity data for impingement analysis. The location of the velocity sensor is important to get the correct measurement. The Duke study computed the approach velocity using the cross-sectional area of the screen that is exposed to the water (varies with the water level at the intake, tide dependent) and the pump flow rate. This does not measure the water velocity at the screen. The screen velocity will vary across its surface and will be dependent on the amount of impinged material that is clogging the screen.

   Board should require that the velocity be measured monthly at lowest predicted tide for the month.

2. Page 8, Description of Cooling Water and Associated Discharges

   This section has been highly edited, eliminating informative details compared to the 2001-383 version. The amount of solids discharged from the forebay cleaning are not provided. The length of the cooling water pipes to the plant (200 feet) has been deleted.

   Bay Council requests that the informative details on the Description of Cooling Water and Associated Discharges from the 2001-383 version be added to this Order.

3. Page 10, Chlorination system description discrepancies. Liquid sodium hypochlorite is injected into the intake pipes immediately upstream of the circulating pumps for each unit. The chlorination system individually controls the injection at each pump every four hours. The chlorine injection is staggered so that no two pumps are chlorinated at the same time. During the injection cycle, each pump is chlorinated for 20 minutes. The chlorination system description, however, does not state the

total number of four-hour cycles in a day. Assuming continuous cycling, there would be six cycles in a day. As there are two circulating pumps per unit, then the injection duration (discharge of residual chlorine) per cycle is 40 minutes. The total discharge duration per unit in one day is 240 minutes or 4 hours. The 40-minute duration contradicts the 20 minutes duration used in determining the residual chlorine given on page 37 of the Fact Sheet.

Bay Council request that the Order provide a full description of the chlorination system including the injection schedule for each four-hour cycle and number of cycles per day for continuous plant operation. We also request that the Fact Sheet provide injection duration times for 1, 2, 3 and 4 units continuously on line.

4. Simultaneous multi-unit chlorination not justified.

   40 CFR Part 423.13 states that the total residual chlorine[49] may not be discharged from any unit for more than two hours in any one day and not more than one unit in any plant may discharge total residual chlorine at any one time unless the utility can demonstrate to the NPDES permit issuing authority that the units in a particular location cannot operate at or below this level of chlorination. Tentative Order Prohibition #9 limits the discharge duration to 2 hours, but then states that "simultaneous multi- unit chlorination is permitted." Given descriptions in the Fact Sheet, our conclusion is that the 2-hour limit is violated. The total chlorination duration per cycle for one unit is 40 minutes times 6 cycles per day for a total duration of 240 minutes or 4 hours.

   Bay Council requests that the Order explain this apparent discrepancy and justify the need for the simultaneous multi-unit chlorination.

5. In order to determine the entrainment losses, the exposure time for the entrained biota in the cooling system should be provided. See Regional Analysis Document for the Final Section 316(b) Phase II Existing Facilities Rule. EPA-821-R-02-003 Chapter A1, Ecological Risk Assessment Framework.

[49] The text of the Tentative Order uses chlorine residual and residual chlorine interchangeably. We use residual chlorine to be consistent with 40 CFR.

Bay Council requests that the Fact Sheet provide data demonstrating exposure times for the entrained biota in the cooling system.

6. Page 30, last paragraph, first sentence. Correct "S2 to S1" to "S1 to S2".

7. Page 36, Total residual chlorine in cooling water discrepancies. The Tentative Order uses the Best Available Technology (BAT) provisions of 40 CFR Part 423.12 for effluent limitations guidelines representing the degree of effluent reduction attainable by BAT. Describe the BAT used to reduce the total residual chlorine. The regression equation on this page is used to determine the total residual chlorine that is discharged into the bay as well as the receiving waters. It is apparent from the form of the equation that it was derived empirically. The Tentative Order should provide full disclosure of the conditions for which this equation applies including the maximum chlorine dosages and justification for the use of this equation to determine for the receiving waters. The Fact sheet on page 37 applies this equation using 80 minutes of uninterrupted chlorine discharge and obtains 0.085 mg/l. The maximum duration of uninterrupted discharge is given as 80 minutes based on 20 minutes per condenser per cycle. As stated in our previous comment on the chlorination system, this duration should be 40 minutes based on our interpretation of the chlorination system injection schedule provided.

8. **Proposed residual chlorine does not comply with State Ocean Plan and EPA national recommended water quality for chlorine.**

   Bay Council compared the State Ocean Plan water quality objectives for protection of aquatic life residual chlorine for intermittent chlorine discharge. Using the 80 minutes for comparison, the value is 0.0096 mg/l. This is almost 9 times lower than the limit of 0.085 mg/l in the Tentative Order. The EPA national recommended water quality criteria[50] for chlorine are 0.013 mg/l maximum concentration and 0.0075 mg/l continuous concentration. These values bracket the values in the

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[50]National Recommended Water Quality Criteria: 2002, EPA-822-R-02-047. Nov. 2002. http://www.epa.gov/waterscience/pc/revcom.pdf

State Ocean Plan. As another point of reference, the Government of British Columbia ambient water quality criteria[51] for controlled intermittent residual chlorine discharge is even more stringent. Applying their criteria for 80 minutes duration, the average value is 0.00353 mg/l.

It should be noted that the Duke draft Vol. I, 316 (a) study dated May 1, 2004 shows on Figure 2.8-2 total monthly residual chlorine levels measured for June to September 2003 in the intake and discharge channel to be about the same ranging from average of 0.020 to 0.042 mg/l. These values are in excess of the EPA criteria.

Consequently, Bay Council does not believe that the proposed residual chlorine allowable limits protect the aquatic life in the San Diego South Bay and strongly recommend that the State Ocean Plan requirements be imposed. De-chlorination should be used if needed to bring the residual chlorine to safe levels in compliance with the Ocean Plan. It is concluded in the Duke studies that the phytoplankton community will not be impacted by contact with the effluent plume because of the temperature tolerance of the species present. No consideration, however, is given to other properties of the plume, in particular the presence of chlorine biocide. Residual chlorine in the discharge will be allowed up to the permitted concentration of 0.2 mg/l (milligrams per liter). As Pisces points out, studies demonstrate that photosynthetic activity is considerably reduced at residual chlorine levels well below 0.2 mg/l and conclude that bacterial activity is suppressed at chlorine levels below detection levels.[52] While chlorination will only be intermittent (not discharged from any single generating unit for more than two hours per day), there will be periods when the effluent will impact the local phytoplankton community. Pisces states that larvae of oysters are also known to be vulnerable to low levels of chlorine.[53] Studies have also demonstrated that chlorine concentrations of 0.05 mg/l caused about 50% of Pacific oyster, *Crassostrea gigas*, larvae to develop abnormally.[54] Furthermore, larvae of American oysters have a

[51] Government of British Colombia, Ministry of Water, Land and Air Protection, *Ambient Water Quality Criteria for Chlorine, Overview Report, Dec 1989*. http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/chlorine.html
[52] See Pisces Report at 8-9.
[53] Ibid.
[54] Ibid.

48h LC50 (the concentration at which 50% of the animals die) of less than 0.005 mg/l.[55]

9. **Bay Council requests that measurements that determine the cross section area as a function of water depth (including tidal variation) at the discharge monitoring location, S2, should be given and where the monitoring point is to be located. In addition, Bay Council requests that a scaled drawing showing the discharge pipes and location of the discharge monitoring location (compliance point) should be provided.** Attachment 1 of the Monitoring and Reporting Program and Attachment 3 of the Fact sheet are not adequate. The purpose of this information is allow one to determine the location and distances from each of the discharge pipes to the compliance point (property line). Describe the flow measuring method and accuracy of the flow measurement.

10. Attachment 6, Reasonable Potential Assessment Results for the online version does not match the distributed printed version. Correct the online version, as it should accurately represent the Tentative Order in order for the public to provide comments prior to the end of the comment period.

[55] Ibid.

Monitoring and Reporting – Specific Comments

1. **Board should require MRP to measure water velocity at intake screens at maximum load period of the day and at low tide.** The purpose is to characterize the screen velocity under worst-case conditions so the sampling can end when there are sufficient samples to meet this end.

2. **Board should require that MRP measure intake flows at each intake pipe and obtain the total intake flow.**

3. MRP paragraph B and C. Dissolved oxygen monitoring influent/effluent is inadequate as it as it fails to measure the diurnal changes in DO by only specifying a grab sample once a month. **Board should require:**

    a. Samples of influent and effluent be taken within the same time period (within 20 minutes or less) with samples taken at 0800, and 1800 hours to measure the diurnal variation of the influent DO

4. Page M-5 footnote states discharger shall monitor of all parameters including temperature at location S2 by expiration of the order. Bay Council agrees that this location is appropriate but we do not think that we should wait until the end of the permit period. This location should be the compliance point effective immediately upon adoption of the Order and issuance of a Cease and Desist Order with a compliance schedule would allow the plant to continue to operate until it comes into compliance. **Board should require that monitoring be conducted at property line with possible exception of flow rates as noted in next comment.**

5. Page M-6 states the effluent monitoring be conducted at location S2. This is problematical in our view because the accuracy of the channel flow depends on the accuracy of the channel dimensions. **Board should require that flow meters located at each discharge pipe to obtain the total flow.** Better flow accuracy can be obtained by this manner. Because there will be concentration gradients of the pollutants being discharged into the channel, provide an assessment of the effluent measurement accuracies.

6. **Board should require Receiving Waters diurnal dissolved oxygen measurements in MRP.** MRP paragraph D, Receiving Waters dissolved oxygen monitoring is inadequate as it fails to measure the diurnal changes in DO by only specifying a grab sample once a month. End Note 4 on page M-11 requirement to measure DO between noon and 5:00 PM does not measure the low DO levels, which occur in the early morning hours. **Board should require:**

   a. Samples of influent and effluent be taken within the same time period (within 20 minutes or less) with samples taken at 0800 and 1800 hours to measure the diurnal variation of the influent DO

7. MRP Receiving Water Monitoring par. D does not specify the time of day to measure water temperature. Purpose should be to select the time of day that has the highest water temperature. This would be in the mid to late afternoon.

8. Acute and chronic toxicity tests are laboratory tests and as such do not reflect the true in-water conditions, in particular, the water temperature and dissolved oxygen. It is well established that the metabolic rate of organisms increases with temperature[56] and thereby can increase the organism's toxic response to pollutants. Because acute and chronic toxicity tests are conducted in the laboratory, the temperature of the water sample is controlled by the test method and will be, in general be lower than the in-situ temperature. Furthermore, the lower temperature will increase the dissolved oxygen in the laboratory tests compared to the in-situ conditions. Section 316(a) requires that the interaction of the thermal component of the discharge with other pollutants be evaluated. Short of conducting these toxicity tests in-situ or maintaining the in-water temperature and dissolved oxygen levels in the test water sample, the results of the acute and chronic toxicity tests that are conducted per the standard protocols can be giving false, optimistic values. **To resolve this dilemma, Board should require that experimental toxicity tests conducted with the water samples taken at the maximum existing temperatures and maintained during the test.**

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[56] See for example Mele. Joseph A. "Thermal Pollution and Aquatic Life," available at http://www.users.nac.net/jmele/TPAL.html

9. Page M-7. **Board should require that the chemical characteristics of the receiving water be monitored for compliance with the limitations listed on page 10 of the Tentative Order**. These include pH, sulfides, un-ionized ammonia and organic materials in the sediments (total organic carbon). The dead and decaying marine life that are captured by the cooling water moving intake screens and discharged into the bay can degrade these chemical parameters.

10. **Board should require that Chlorophyll (a), total suspended solids and BOD be monitored at the discharge channel and intake channel to assure compliance with the chemical characteristics of the receiving waters.** The NOAA report on the workshop for sea grass light requirements[57] recommends these requirements.

11. Describe the method and instrumentation used to measure effluent flow.

12. Page M-12. Endnote Reference 9 specifies the same method or measuring the residual chlorine in the effluent and the receiving water. As previously commented, the receiving waters monitoring and method to obtain the total residual chlorine must be changed. Given the transport time of the effluent, the monitoring order of the stations should be specified for consistency of the data. Revise the Monitoring and Reporting Program. Page M-8 footnote for monitoring for total chlorine residual requires only two stations. **Board should require that additional stations be included.** These are the far field station N2 and F3. The reason is that the residual chlorine levels given in the discharge summary on page 14 of the Fact Sheet and as reported in the Duke 316(a) report are in excess of the State Ocean Plan as well as the EPA national recommended water quality for residual chlorine.

13. **Board should require additional seasonal, quarterly benthic invertebrate sampling.** This consists of taking and analyzing the invertebrate infauna from minimum of five replicates, 0.1 m^2 Van Veen grab samples at a series of stations within and outside the extent of the thermal plume including

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[57] NOAA Technical Memorandum NMFS-SEFC-287. *The Light Requirements of Seagrasses. Results and Recommendations of a Workshop.* June 1991 http://shrimp.ccfhrb.noaa.gov/research/nmfs-sefc-tm287.pdf See page 16.

Station F3 and N2. The invertebrate infauna samples shall be analyzed using the methods of the Ford and Chambers 1972-73 study[58] and summarized per the E.A. Engineering, Science, and Technology 1995 report [59].

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[58] Ford and Chambers, *Thermal Distribution and Biological Studies for the South Bay Power Plant*, May 1973

[59] E.A. Engineering, Science, and Technology. (EAEST*), South Bay Power Plant Receiving Water Monitoring Program with Emphasis on the Benthic Invertebrate Community (1977-1994).* 1995

Other Comments

A. Need for Substantial Mitigation of SBPP Impacts

Over the past four decades, the adverse impacts of the plant have been subsidized by San Diego Bay and the people of the State by the fact that the plant has been allow to operate in a manner that impacts the bay's resources without mitigating those impacts. The time for that subsidy is over.

Bay Council recommends that the Board adopt a permit that will reflect the real cost of using San Diego Bay water for cooling an inefficient and archaic power plant. The Tentative Order does not contemplate or require significant mitigation. Bay Council recommends that the Board revise the Tentative Order to include the need for mitigation. Bay Council believes that mitigation funds should go to support new, energy efficient, and sustainable technology and greatly improved protection of water quality and marine life. We strongly urge the Regional Board to require mitigation of these impacts by requiring funding or Supplemental Environmental Projects that reduce energy loads and improve habitat in the Bay.

B. Cease and Desist Order

Bay Council request the Board adopt a Cease and Desist Order ("CDO") into this Tentative Order. A CDO is an appropriate tool the Board can use to provide a time schedule to achieve full compliance for a discharger who cannot immediately comply with permit requirements. The adoption of a CDO will ensure that Duke will be allowed to continue to operate even though they cannot be in immediate compliance with its permit requirements, while setting a reasonable time schedule to achieve compliance and imposing appropriate penalties if compliance is not attained.

C. Sea Turtles in SBPP Discharge Canal

According to Serge Dedina, Phd., Executive Director of WiLDCOAST, although turtles do enjoy congregating in the discharge canal of SBPP, there is no scientific proof that this is beneficial or crucial to the turtle population in San Diego. First, no turtles have been documented to breed in the area. Instead, they come to play, and feed on eelgrass. As Pisces, Duke, and Tetra Tech point out, we have definitive proof that eelgrass populations are being adversely impacted by SBPP's thermal discharge. As a result, abating the discharge would actually increase eelgrass and provide more food for turtle populations, thus benefiting the turtle population in the region for the long term. As far as experts working on protecting sea turtle populations, they believe that the more important keys to protecting the sea turtle population are improving the health of the ecosystem and preventing direct (poaching) and indirect (caught in fish nets) takes, which account for a large percentage of turtle mortality in the region (especially in Baja California where a black market exists for poaching) and worldwide. Furthermore, it has been observed that *fibropapilloma* is a major problem for sea turtles worldwide and regionally, and scientist believe that it is due to poor water quality. Therefore, ending or abating the thermal discharge at SBPP would, in the long run, improve turtle population and health by improving water quality and improving the ecosystem (more eelgrass presumably) that the turtles live in.

C. Other Problems Related to Release of Duke Studies and Tentative Order to Public

Bay Council would like to raise a number of issues related to the release of the Tentative Order and its supporting documents to the Public. The Tentative Order appears to rely heavily on information provided to the Board by the Duke Studies. The Studies, however, have many flaws which prevent it from being wholly useful to the public. For example, to this date, a final copy of the Studies has yet to be released to the public. Only draft copies of the Studies are available to the public. This is problematic on a number of levels. First, if the Studies are the primary basis of justification for the findings of the Tentative Order, the public needs to have a final copy available to review. Second, on May 19th, 2004 the Board held a workshop on the Studies. Comments from the public on the Studies were taken by the Board with the intention that they would be reflected and/or addressed in the Studies. However, to this date, those comments have not been responded to.

Other missing key information from the Duke Studies and Tentative Order included:

1. Duke Studies

   a. Appendix I, Table I3, was incomplete and missing invertebrate data for stations ST1, ST2, ST3, ST4 and ST5.

b. No description of how discharge flows given in the Studies were obtained.

c. There was important missing data on the entrainment losses. Specifically, data regarding exposure time for the entrained biota in the cooling system.

2. Tentative Order and Fact Sheet

a. Fact sheet, Page 1 information is missing regarding test data and calculations used to obtain the new effluent limitations for total recoverable copper.

b. Fact sheet, Page 6 of Tentative Order No. R9-2004-0154 refers to Tetra Tech's evaluation and its recommendations to the Board regarding Duke's compliance with 316(a) and (b). This document was not openly available to the public. Bay Council obtained, however, through a public records request.

Conclusion

As stated earlier, although there are some portions of the Tentative Order that Bay Council believes are a vast improvement from the previous Tentative Order, we must strongly oppose the adoption of this permit, unless it is amended as described in this letter.

In its current form, it allows the plant to operate for at least another 2-3 years at a level which significantly impacts the San Diego Bay and is inconsistent with existing regulations under the law. In addition, we believe that the SBPP is not in compliance with 316(b) – new and old rules – which further necessitates the adoption of a permit that sets appropriately stringent requirements, as required by law, that protect the Bay.

Bay Council urges the Board to take this opportunity to take action now, not wait for Duke to complete more studies at the expense of the Bay. We request that the Board adopt our recommendation for new Dissolved Oxygen and Temperature requirements, as well as other measures that we believe will bring the SBPP in to compliance with the law.

We appreciate the opportunity to comment on this important permit and look forward to the adoption of a permit that protects and restores our Bay.

Sincerely,

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Environmental Health Coalition

Gabriel Solmer, Esq.
Staff Attorney
San Diego Baykeeper

Ed Kimura
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Mike McCoy
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cc:

Mr. John Phillips, Senior WRC Engineer
Mr. Hashim Navrozali, WRC Engineer
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Notes on the South Bay Power Plant (SBPP) 316 a & b application

R M H Seaby

Version 3

29 July 2004

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Aim: to identify the main ecological issues arising from the 316 a & b reports by South Bay Power Plant.

Pisces Conservation Ltd. reviewed the studies prepared by Duke entitled South Bay Power Plant Cooling Water System Effects on San Diego Bay (Volume I and II). Specifically, Pisces was asked to review whether the studies justify findings for compliance under section 316(a) and (b) – new and old rules – of the Clean Water Act. In this document we highlight areas of concern that we identified from the Duke 316 studies.

The EPA has long recognised that some habitats are far more sensitive than others to the effect of cooling water extraction, and has noted the particular vulnerability of estuaries and the littoral zone.

A key aspect of any argument in favour of closed-cycle cooling or other technology must be the reduction of the ecological impacts caused by direct cooling. It is therefore essential that those favouring the introduction of new technologies establish that the existing direct-cooled power plant does have a detrimental effect. To some extent this is clear as we have direct observational evidence of entrainment and impingement mortality and the effect of the discharge on the localised environment. However, the spatial extent of the impact and the longer-term effects on populations are less clear as the biological studies have not been undertaken in a way that is likely to reveal them. However, as will be developed below, there are reasonable grounds for suspecting that the impact may have been greater than the negligible levels claimed.

The evidence in favour of an appreciable effect is reviewed below.

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Executive Summary

This report presents a response to Duke South Bay Power Plant (SBPP)'s 316 (a) and (b) reports in the context of actual and potential damage to the ecosystem of San Diego Bay. In our opinion SBPP do not meet the standards required for 316(a) and either the new or the old 316 (b) regulations.

The SBPP extracts a significant portion of the volume of the South San Diego Bay each day (approximately 20%), and is capable of extracting the entire seawater contents of San Diego Bay in approx 62 days.

We demonstrate that SBPP has had and is having an Adverse Environmental Impact and has failed on most of the steps required to avoid an Adverse Environmental Impact as defined by the EPA.

Impacts of the SBPP are related to a) impingement of animals on filter screens, b) entrainment in the cooling water flow, c) temperature of outfall water, d) biocide content of outfall water, d) leachate content of outfall water, e) collection of dead animals, f) attraction of predators & scavengers, g) oxygen content of outfall water, h) increased sediment load.

About 10% of the eelgrass in the Bay has already been lost and it is likely that a larger area still is growing and reproducing sub-optimally. Eelgrass is a very important component of the Bay ecosystem both in terms of habitat creation and food provision, especially for endangered least terns *Sterna antillarum* and halibut Paralichthys californicus.

The distribution and abundance of nematode and oligochaetes indicates that the ecosystem near the outfall already has reduced biodiversity and is highly stressed. As much as 27% of some larval fish are currently entrained by the SBPP – impacts of this magnitude are unsustainable.

Chlorine biocide concentrations well below permitted levels are known to damage bacterial and photosynthetic activity and to kill or suppress reproduction in zooplankton.

Detrimental impacts on the populations of a species can have ramifications for all the other species that interact with them, be they prey, predator, parasite or competitor. These effects might not be directly or easily quantifiable.

This report also refutes the often-quoted concept of surplus production – that natural populations exhibit a huge potential to sustain cropping and therefore can withstand the losses caused by the operation of the plant. We maintain that this argument fallaciously rests on principles developed in agricultural and domestic scenarios and have no relevance in nature where natural variability plays a central part in determining populations.

We conclude that SBPP is not in compliance with 316(a) and (b) – old and new rules – of the Clean Water Act.

Ability to Meet New 316 (b) Requirements

To meet the new 316 b regulations for existing facilities, the applicant can either demonstrate that certain performance standards are reached or alternatively a site-specific determination can be undertaken to demonstrate BTA.

Performance Standards.

(1) You must reduce your intake capacity to a level commensurate with the use of a closed-cycle, recirculating cooling system; or
(2) You must reduce impingement mortality of all life stages of fish and shellfish by 80 to 95 percent from the calculation baseline if your facility has a capacity utilization rate less than 15 percent, or your facility's design intake flow is 5 percent or less of the mean annual flow from a freshwater river or stream; or
(3) You must reduce impingement mortality of all life stages of fish and shellfish by 80 to 95 percent from the calculation baseline, and you must reduce entrainment of all life stages of fish and shellfish by 60 to 90 percent from the calculation baseline if your facility has a capacity utilization rate of 15 percent or greater and withdraws cooling water from a tidal river or estuary, from an ocean, from one of the Great Lakes, or your facility's design intake flow is greater than 5 percent of the mean annual flow of a freshwater river or stream; or
(4) *If your facility withdraws cooling water from a lake (other than one of the Great Lakes) or reservoir: (i) You must reduce impingement mortality of all life stages of fish and shellfish by 80 to 95 percent from the calculation baseline; and (ii) If you propose to increase your facility's design intake flow, your increased flow must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water, except in cases where the disruption is determined by any Federal, State or Tribal fish or wildlife management agency(ies) to be beneficial to the management of fisheries.*

Federal Water Pollution Control Act, as amended though PL 2002

In the case of the SBPP proposal, if the performance standard approach is chosen then they must either reach closed-cycle levels of impact or reduce impingement mortality by 80 to 95 % and reduce entrainment of all life stages of fish and shellfish by 60 to 90 %.

Site-Specific Determination of Best Technology Available.

(1) If you choose this alternative you must demonstrate to the Director that your costs of compliance with the applicable performance standards in paragraph (b) of this section would be significantly greater than the costs considered by the Administrator when establishing such performance standards, or that your costs would be significantly greater than the

benefits of complying with such performance standards at your site.

(2) *If data specific to your facility indicate that your costs would be significantly greater than those considered by the Administrator in establishing the applicable performance standards, the Director shall make a site specific determination of best technology available for minimizing adverse environmental impact that is based on less costly design and construction technologies, operational measures, and/or restoration measures to the extent justified by the significantly greater cost. The Director's site-specific determination may conclude that design and construction technologies, operational measures, and/or restoration measures in addition to those already in place are not justified because of significantly greater costs.*

(3) *If data specific to your facility indicate that your costs would be significantly greater than the benefits of complying with such performance standards at your facility, the Director shall make a site-specific determination of best technology available for minimizing adverse environmental impact that is based on less costly design and construction technologies, operational measures, and/or restoration measures to the extent justified by the significantly greater costs. The Director's site-specific determination may conclude that design and construction technologies, operational measures, and/or restoration measures in addition to those already in place are not justified because the costs would be significantly greater than the benefits at your facility.*

Based on the data presented in the Duke studies, we conclude that the SBPP fails to meet the performance standard approach since the plant is not operating at closed-cycle levels of impact or reducing their impingement mortality by 80 to 95 % and reducing entrainment of all life stages of fish and shellfish by 60 to 90 %. As a result, we assume that in order for SBPP to come into compliance, it will have to seek a site-specific determination of best available technology.

Ability to Meet Old 316(b) Requirements

U.S. EPA provided notes on how to assess an intake under the old 316(b) rules. (Quotes in this section are taken from Guidance For Evaluating The Adverse Impact Of Cooling Water Intake Structures On The Aquatic Environment: Section 316(B) P. L. 92-500 U.S. Environmental Protection Agency, 1977). If the intake is shown to have a high impact on the environment as argued above, and as outlined in the EPA definition of an Adverse Impact, then steps must be taken to reduce its impact.

Adverse Environmental Impact

Adverse aquatic environmental impacts occur whenever there will be entrainment or impingement damage as a result of the

operation of a specific cooling water intake structure. The critical question is the magnitude of any adverse impact.
The magnitude of an adverse impact should be estimated both in terms of short-term and long-term impact with reference to the following factors:

(1) *Absolute damage (# of fish impinged or percentage of larvae entrained on a monthly or yearly basis);*
(2) *Percentage damage (% of fish or larvae in existing populations which will be impinged or entrained, respectively);*
(3) *Absolute and percentage damage to any endangered species;*
(4) *Absolute and percentage damage to any critical aquatic organism;*
(5) *Absolute and percentage damage to commercially valuable and/or sport fisheries yield; or*
(6) *Whether the impact would endanger (jeopardize) the protection and propagation of a balanced population of shellfish and fish in and on the body of water from which the cooling water is withdrawn (long term impact*

The loss of a significant percentage of a critical organism such as eelgrass is covered by section 4 of the above. The loss of a large proportion of some species of fish is covered section 2. This report will detail evidence of these losses, and others that the Duke studies failed to identify, in later sections.

In the event of an Adverse Environmental Impact, a series of steps to undertake is provided, in order to ensure compliance.

- *The first step should be to consider whether the adverse impact will be minimized by the modification of the existing screening systems.*
- *The second step should be to consider whether the adverse impact will be minimized by increasing the size of the intake to decrease high approach velocities.*
- *The third step should be to consider whether to abandon the existing intake and to replace it with a new intake at a different location and to incorporate an appropriate design in order to minimize adverse environmental impact.*
- *Finally, If the above technologies would not minimize adverse environmental impact, consideration should be given to the reduction of intake capacity which may necessitate installation of a closed cycle cooling system with appropriate design modifications as necessary.*

In our assessment, the SBPP fails on most of these steps. First, the existing screening system is the only feasible one considering the large volumes of water passing through the system. Fine mesh and wedgewire screens are probably impractical with this volume and in this situation. Second, the fact that the screens are not rotated continuously (section 4.2.1 paragraph 2 SBPP Cooling water systems effects on San Diego Bay. volume II) means that the survival probability of any impinged fish returned to the discharge canal will be lower than is technically possible. Finally, the intake velocity and position of the intake are fundamental design parameters of the system and could only be altered by using less cooling water or reengineering the intake configuration.

Later in the guidance notes the EPA refers to 'habitat formers' and describes them as "critical to the structure and function of the ecological system".

> *Habitat formers are plants and/or animals characterized by a relatively sessile life state with aggregated distribution and functioning as:*
>
> *1. a live and/or formerly living substrate for the attachment of epibiota;*
> *2. either a direct or indirect food source for the production of shellfish, fish, and wildlife;*
> *3. a biological mechanism for the stabilization and modification of sediments and contributing to processes of soil buildings;*
> *4. a nutrient cycling path or trap; or*
> *5. specific sites for spawning, and providing nursery, feeding, and cover areas for fish and shellfish.*

It is our assessment, which will be detailed in later sections of this Report, that the impact that the SBPP has on the eelgrass in the bay impinges on its functioning under section 3.

The EPA also refers to High Potential Impact Intakes:

> *High potential impact intakes are those located in biologically productive areas or where the volume of water withdrawn comprises a large proportion of the source water body segment or for which historical data or other considerations indicate a broad impact.*

Again this definition is applicable to SBPP, which is capable of taking a significant proportion of the water in the Bay through its intake each day.

From the above points it is our assessment that SBPP does not comply with the old

Impacts Related to Effluent Discharge

To assess the impact of the intake and outfall of SBPP in relation to the 316 (a) and (b) regulations many factors must be taken into account.

It is normally the case that onshore outfalls such as that used at the SBPP have a greater impact than offshore outfalls because the warm and sometimes chlorinated effluent stream is more likely to impact the benthic community. There is a number of ways in which an effluent discharge influences the receiving water and seabed. The most important of these potential effects are itemised below:

- The warming (and rapid cooling when the plant ramps up and down) effect on benthic communities.
- The effect of chlorine and chlorination products on benthic and planktonic organisms.
- The effect of the 'rain' of dead and damaged animals that have been entrained or broken up by the cooling water system on the receiving ecosystem.
- The attraction of predatory and scavenging organisms into the outfall region.
- Changes in water quality linked to differences in nutrient levels, pollutants, salinity etc. between the water in the intake and outfall areas.
- The impact of outfall canals and structures.
- The impact of general reduced water quality e.g. reduction in dissolved oxygen, increased sediment load and leachates from cooling water system.

From the studies undertaken and reported by Duke, it is difficult to assess the impact of the effluent discharge on the local ecosystem because no data are presented on the state of the communities prior to the establishment of the outfall. Thus the only means available to detect ecological impacts is the detection of trends with distance from the outfall. This approach is problematic, however, as other uncontrolled physical factors, such as water exchange with the open sea and other anthropomorphic effects, will also be changing with distance. The result is that only large, visually apparent, effects are likely to have been detected. This problem is particularly apparent in the beach and offshore benthic samples where variation in animal abundance and diversity linked to natural changes in the substrate may mask any trend linked to distance from the outfall. All that can really be stated with certainty is that the sampling stations show considerable variability and that sampling stations nearest to the outfall are different from some of those that are further away. There are however indications that sampling stations closest to the outfall differ in animal composition from all others.

Duke Study Fails to Fully Assess the Impact of Chlorine in Discharge

It is concluded in the Duke studies that the phytoplankton community will not be impacted by contact with the effluent plume because of the temperature tolerance of the species present. This may or may not be true. However, no consideration is given to other properties of the plume, in particular the presence of chlorine biocide. Residual chlorine in the discharge will be allowed up to the permitted concentration of 0.2 mg/l (milligrams per litre). Davis & Coughlan (1978) demonstrated that photosynthetic activity was considerably reduced at residual chlorine levels well below 0.2 mg/l and concluded that bacterial activity was suppressed at chlorine levels below detection levels. While chlorination will only be intermittent, there will be periods when the effluent will impact the local phytoplankton community.

Similar concerns to those expressed above for the phytoplankton also apply to the zooplankton. Zooplankton show severe metabolic and reproductive suppression after exposure to chlorine at levels as low as 0.01 mg/l in seawater (Goldman et al. 1978). Davis & Coughlan (1978) reported that 48 hr after exposure to a concentration between 0 and 0.25 mg/l, 22 % of adult copepods were dead.

The larvae of oysters are also known to be vulnerable to low levels of chlorine. Chlorine concentrations of 0.05 mg/l caused about 50% of Pacific oyster, *Crassostrea gigas*, larvae to develop abnormally (Bamber & Seaby, 1997). The larvae of American oysters have a 48h LC50 (the concentration at which 50% of the animals die) of less than 0.005 mg/l (Mattice & Zittel, 1976).

Effect on the Fish Fauna of the Discharge Area.

The data presented by the Duke studies suggest that the outfall is influencing fish abundance. In the zone close to the discharge point, the studies pointed out the abundance of fish was higher than that observed at control stations. The study stated that itt was dominated by large numbers of juvenile slough and deepbody anchovy.

The aggregation of fish in the vicinity of outfalls, however, is a commonly observed feature usually linked to the presence of food in the form of debris from impinged animals and dead, injured or disorientated plankton that have passed through the station. The currents produced by cooling water discharges also offer a situation where faster swimming predatory fish can hold an appreciable advantage over their prey. This is not to say that these fish themselves will not be harmed by temperature changes near the outfall as the plant goes on- and off-line.

Duke Study Understates Impact of Copper in Discharge

Copper, even at low discharge levels, bioaccumulates from the environment into higher animals. Copper from the SBPP is released by leaching from the condenser tubes from units 3 and 4. Unit 1 is a high performance stainless steel containing alloying elements of chromium, molybdenum and nickel. Unit 2 condenser tubing is aluminum brass, and Units 3 and 4 have copper-nickel tubing. Any copper release is likely to stay within the bay and accumulate through the food web.

Duke Study Fails to Adequately Assess Impact of Severe Eelgrass Damage

To be in compliance with 316(b), both old and new editions, there must be no significant degradation of the environment. The operation of SBPP has resulted in the loss of 10% of the eelgrass in the Bay.

Eelgrass is very efficient at converting solar energy into plant tissue. During this process it concentrates numerous elements that occur at low concentrations. With its high productivity and rapid growth, eelgrass forms the food-base for fish, shellfish and waterfowl in shallow seas, as plankton does for marine life in deeper waters.

The thermal and chemical impact of the SBPP has reduced the amount of eelgrass present in the bay.

From Fact Sheet for Public Tentative Order No. R9-2004-0154 NPDES Permit No. CA0001368:

> *"The predicted turbidity effects of the SBPP cooling water flows suggests that the SBPP, operating at maximum cooling water circulation rates (i.e. 601.13 MGD) would preclude eelgrass from approximately 104 acres of south San Diego Bay. At the mean summer 2003 operating conditions of 441 mgd, the SBPP is predicted to preclude eelgrass from approximately 71 acres of south San Diego Bay through its cooling water discharge effects on naturally-generated turbidity."*

This loss represents about 10% of the eelgrass habitat of the entire bay. If the power plant is excluding eelgrass totally from an area there must be a much larger area that is growing sub-optimally. The loss and sub-optimal growth of eelgrass within the bay is likely to impact on the community structure as a whole.

The loss of the eelgrass from an area will significantly change the environment and the community of organisms living in that area. In an Order issued by the California Regional Water Quality Control Board, San Francisco Bay Region they state:

> *Eelgrass beds are important components of estuarine ecosystems, and have declined from historical levels both globally and in the San Francisco Bay. Eelgrass restoration projects should therefore be encouraged in the region in order to increase water clarity, reduce erosion, provide nurseries for fish, and increase habitat for invertebrates, in shallow water coastal habitats.*

This indicates that the State has recognised the importance of eelgrass and where possible are working to increase the total overall area of this ecotype.

Diane Gussett from the Port Townsend Marine Science Center in Washington (www.ptmsc.org/html/eelgrass.html) summarises the importance of eelgrass in modifying the habitat. It:

- *Creates a highly structured habitat from loose and shifting sands.*
- *Softens the impact of waves and currents, stabilizing the shoreline and providing a calm space where organic matter and sediments are deposited.*
- *Provides shelter and protection from predators for many juvenile fish and shellfish of ecological, commercial and recreational importance.*
- *Absorbs and concentrates nutrients from the sea and transfers them to the sediment or to animals.*
- *Decomposes into an important part of the food web for the coastal marine ecosystem.*
- *Provides diverse habitats.*
- *Provides an important pathway for food for both local and distant communities*

This natural modification of the environment, caused by the growth of eelgrass, results in an increase in productivity. Bare sand has a lower diversity and a lower abundance of fish than sites with eelgrass present (Murphy *et al,* 2000). It is not only fish that can benefit from the presence of eelgrass. The leaves, stems, roots and rhizomes provide multiple habitats and support a great variety of animals living in, above, and under but not directly feeding on, the eelgrass. Much of the production used by the community living on and around the eelgrass not only consumes the eelgrass but also consumes the epiphytic covering of algae and bacteria. The health of this layer is also important to the productivity of the eelgrass beds. This layer is vulnerable to pollution, both thermal and chemical.

One of the main functions of eelgrass is the production of detritus. The eelgrass fragments are ingested and egested several times, each time becoming smaller and therefore available to a different part of the food chain. The nutrition obtained by the animals consuming these fragments is derived both from the plant itself and the microbial colonisation of the fragments.

In 1930 and 31 much of the Atlantic Coast eelgrass population was killed by wasting disease. The effects were dramatic and wide-ranging:

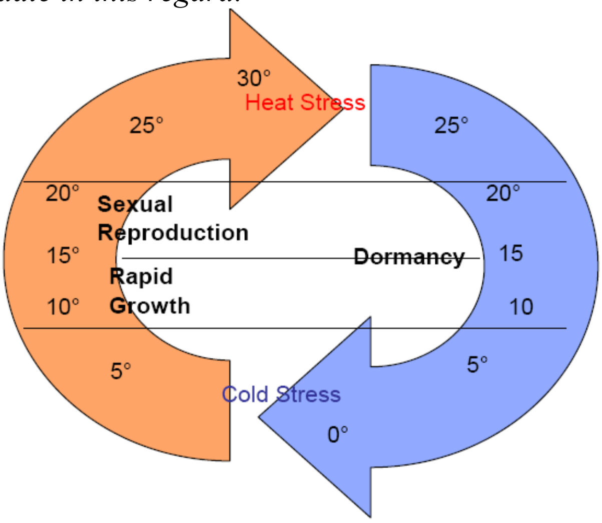
> *To appreciate the ecological importance of seagrasses, consider the sudden disappearance of eelgrass beds along the Atlantic coast during the 1930s. An epidemic infestation of the parasitic slime fungus (Labyrinthula), called "wasting disease," literally destroyed the rich eelgrass meadows, the results of which were catastrophic. Populations of cod, shellfish, scallops and crabs were greatly diminished, and the oyster industry was ruined. There was also a serious decline in overwintering populations of Atlantic brant. Areas formerly covered by dense growths of eelgrass were completely devastated and beaches which had been protected from heavy wave action were now exposed to*

storms. Without the stabilizing effects of eelgrass rhizomes, silt spread over gravel bottoms used by smelt and other fish for spawning. This resulted in a decline in waterfowl populations that fed on the fish. Without the filtering action of eelgrass beds, sewage effluent from rivers caused further water pollution, thus inhibiting the recovery of eelgrass.

(From http://waynesword.palomar.edu/seagrass.htm a web site run by Professor Armstrong at Life Sciences Department of Palomar College)

Studies into the effects of temperature on eelgrass have a long history. As early as the 1920s studies were performed analysing the life cycle of eelgrasses and the effect of temperature.

Based on Setchell's field observations, the relationship between temperature and phenotypic status is given in Figure 2. Field collections were frequently made through 1923-24 at Kiel and Paradise Coves (Setchell 1929). This investigation convinced Setchell that temperature was the primary controlling factor in eelgrass reproduction. In essence, he argued that as temperatures warmed in spring, vegetative growth (and seedling germination began). When temperature reached 15° C sexual reproduction was initiated. Growth slowed as water temperature increased and prolonged exposure to 30° C could result in shoot mortality. Setchell was struck by the fact that as temperatures cooled, the plants did not respond by resuming growth but rather became dormant and did not exhibit a growth response until the following spring and associated temperature increase (Setchell 1929). Phillips et al. (1983) concluded that while water temperature was a factor there were other factors controlling eelgrass phenology[1], a position that is widely accepted but untested, although the influence of photoperiod is a likely candidate in this regard.



[1] **Phenology** is the study of the annual cycles of plants and animals and how they respond to seasonal changes in their environment.

__Figure 2__. Graphic illustration of Setchell's topology describing the relationship between temperature and eelgrass phenology (Re-drawn from Setchell 1929).

(From the Office of Response and Restoration website
http://response.restoration.noaa.gov/cpr/watershed/sanfrancisco
/sfb_html/pdfs/projectreports/partnership_seagrassrev_fin.pdf)

The most notable aspect of this description is that eelgrass does not return to growth and reproduction after being subjected to heat stress. It is therefore likely that eelgrass which has been stressed by the SBPP thermal outfall will not reproduce.

In 1986 Marsh *et al.* measured the changes in eelgrass photosynthesis and respiration rates at 8 temperatures between 0 to 35C. He found that 5C was the optimum temperature for the growth of eelgrass. At 30C the respiration rate of the eelgrass exceeded the rate of photosynthesis resulting in negative growth. These experiments were done in clear water. In turbid water, such as is now found in the South Bay, the rate of photosynthesis will be reduced. Hence the switch point between positive and negative growth will occur at lower temperatures. For example,

> *Bulthuis (1987) examined the effect of temperature on seagrass photosynthesis rates at low light levels. He showed that optimum temperature for photosynthesis in* Heterozostera tasmanica *decreased from 35^{o}C at light saturation to 5^{o}C at reduced light levels.*

(From http://www.epa.gov/region1/braytonpoint/pdfs/BRAYTONchapter6.PDF – including Marsh *et al* 1986 reference.)

Although Bulthuis was working on an Australian species, it is likely that a similar compensation point (where photosynthesis equals respiration) will apply for North American species.

In conclusion, eelgrass is a habitat-modifying species. As such it has a very significant effect on the habitat and community of the Bay. It creates organic material that in turn supports a complex food web of detritivores and consumers. It is used for shelter by many fish species, and is an important food and habitat for birds.

It is affected by temperature and suspended solids; large areas have been lost due to the operation of the SBPP. Other areas may be growing less well than they would without the effect of the power plant. The ramifications of this loss are complex and difficult to quantify.

Benthic Studies Are Crucial to Determining Ecological Impact of SBPP

SBPP has affected the benthos in the Bay. It has had effects that are measurable and are likely to be affecting the production of the habitat in the vicinity of the power plant.

The high biomass of nematodes and oligochaetes in the benthic samples around the outfall of the plant indicates that the system is highly stressed. Dominance by nematode and oligochaetes is usually a sign of organic enrichment and subsequent low oxygen (due to high levels of bacterial respiration). Diversity increases (i.e. the relative importance of these worms decreases) with distance down the discharge channel.

It is known that low diversity habitats with high abundance of pollution-tolerant species such as nematodes and oligochaetes are a sign of a disturbed or polluted environment. See table below.

Table 1. Potential indicators of benthic stress.

Non-Disturbed Environments:	
Environmental Characteristics	**Biological Characteristics**
- Low Total Organic Carbon (<1%)	- High number of species
- High RedOx potential (positive Eh values)	- High Diversity (H')
- Low porewater sulfide (< 0.01 mg/L unionised H_2S)	- High total faunal abundance
- Low porewater ammonia (< 0.2 mg/L unionised ammonia N)	- High biomass
- High bottom water dissolved oxygen (> 5 mg/L)	- High species evenness/low dominance
- Low measures of sediment contamination:	- High Nos. of long-lived/equilibrium & pollution- sensitive species
- Low chloroform extractable bitumen (< 1 mg/g)	- Low Nos. of opportunistic and pollution-tolerant species
- Individual chemical concentrations less than sediment quality guideline values (ERM, PEL values).	- Higher ratio of filter feeders to carnivores and deposit-feeders
	- Higher multi-metric benthic index score
	- Diverse age-class structure
- Low mean ERM quotient (< 0.01)	- Low incidence of morphological anomalies
- No sediment toxicity in standard bioassays with ambient amphipod	- Higher ratio of crustaceans to polychaetes and molluscs
	- Low abundance/biomass ratio
	- Low abundance/ species ratio
	- Low incidence of internal parasites (esp. molluscs)
Heavily Disturbed Environments:	
Environmental Characteristics	**Biological Characteristics**
- High Total Organic Carbon (> 3%)	- Low number of species
- Low RedOx potential (negative Eh values)	- Low Diversity (H')
- High porewater sulfide (> 0.05 mg/L unionised H_2S)	- Low total faunal abundance
- High porewater ammonia (> 0.4 mg/L unionised ammonia N)	- Low biomass
- Low bottom water dissolved oxygen (< 2 mg/L)	- Low species evenness/high dominance
- High measures of sediment contamination:	- Low Nos. of long -lived equilibrium & pollution-sensitive species
- High chloroform extractable bitumen (>10 mg/g)	- High Nos. of opportunistic and pollution-tolerant species
- Individual chemical concentrations greater than sediment quality guideline values (ERM, PEL values).	- Lower ratio of filter feeders to carnivores & deposit-feeders
	- Lower multi-metric benthic index score
	- High incidence of morphological anomalies
- High mean ERM quotient (> 0.1)	- Lower ratio of crustaceans to polychaetes and molluscs
- Significant sediment toxicity	- High abundance/biomass ratio
	- High abundance/ species ratio
	- High incidence of internal parasites (esp. molluscs)
	- Higher incidence of younger forms
	- Presence of beggiatoa-like mats
	- High incidence of imposex
	- Abnormal occurrence of infauna relative to sediment depth (high density of deep burrowing fauna on surface).

Note: Other features to consider include:

1. Abiotic factors to help interpretation of data on biological and environmental (stressor) variables such as grain size, C/N ratios, chlorophyll a/phaeopigment ratios, and acid volatile sulfides.
2. Seasonality.

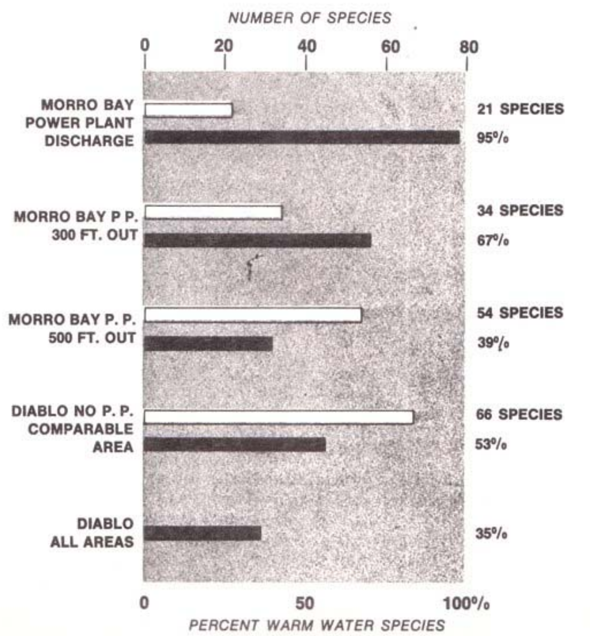
(From Intergovernmental Oceanographic Commission - technical series. *Ad Hoc* Benthic Indicator Group, Results of Initial Planning Meeting, Paris, France 6-9 December 1999)

The SBPP power plant will cause a reduction in diversity in several ways. The outfall could eliminate species that:

1. cannot withstand the temperatures found in the area impinged by the outfall.
2. cannot withstand the lower oxygen levels in the area, caused by a) the elevated temperatures and b) the “rain” of dead and dying organisms released by the plant by entrainment and plant washing.
3. cannot withstand the elevated suspended solids found in the area
4. are killed by the presence of biocides in the outfall water
5. are killed by other chemicals leaching from the plant.

Even if species can live within this zone, they might be living sub-optimally and possibly not be able to reproduce. Often, where the temperature of the water is below the thermal death point of the organism, it can have deleterious effects such as increasing growth rates, prolonging the growth season, causing earlier breeding (Barnett, 1971) or causing avoidance behaviour (Naylor, 1965).

Other outfalls have been shown to reduce the diversity of the invertebrates found in the sediments. For example at Morro Bay, California, the number of invertebrates was identified from the discharge zone and at 300 and 500 feet from the end of the discharge. This was compared to a control site along the coast. The control site had 66 species present. The samples from Morro Bay had 21, 34 and 54 species - respectively. Interestingly, 95 % of the species found in the samples closest to the discharge were identified as warm water species (See figure below from Adams, 1969).



INVERTEBRATES COLLECTED AND IDENTIFIED AT MORRO BAY POWER PLANT AND AT DIABLO (NO POWER PLANT)

A Very High Percentage of the Volume of the Bay Affected

In the old regulations, specific mention was made of an intake that "*comprises a large proportion of the source water body segment.*" This is obviously the case for SBPP.

A high percentage of the volume of the water in zone 4 is potentially passed through the power plant. The volume of zone 4 (the zone in which the plant is operating) is 20,410,508 m^3. SBPP, when operating at full capacity, uses 1,580m^3 per minute. In one day the plant uses (60*24*1580) 2,275,200 m^3. This is 11% of the water in zone 4 per day. The volume of the entire San Diego bay is 140,612,092m^3, which means that the plant is utilising 1.6% of the bay per day. The plant could pass the equivalent of the entire bay thorough the cooling water system every 62 days, or about 6 times a year.

SBPP give the average water flow during December 1998 to September 2003 as 425,056m^3. This still represents 2% of the southern bay per day. This number has to be treated with caution as the figure 2.1.2 in 316b report from SBPP shows that the plant operates at or near full capacity for quite long periods. Since planktonic stages in fish are fairly short lived the effect on some species might be greater that the 2% figure suggests. For a more accurate figure it would be necessary to determine the actual flows during the period during which each species is vulnerable to entrainment.

Impingement and Entrainment

The SBPP intake within San Diego Bay acts as a suppressor on the ecosystem, continually removing and killing a wide variety of organisms. Because intakes tend to kill disproportionately large numbers of small animals and juveniles, they tend to impoverish the standing crop in the lower trophic levels towards the base of the ecosystem. The ecosystem in the vicinity of an intake gradually distorts under this unnatural mortality. Given sufficient time, an un-natural equilibrium community adapted to the artificial conditions may develop. However, this may take many years, and other changes are also probably occurring simultaneously. There are no data sets presented by the Duke studies that attempt to quantify the extent of these changes.

Within a restricted water body, such as San Diego Bay, where the plant can utilise the total volume of water in the bay every 60 days, impingement and entrainment mortality has the potential to reduce the local population by a significant amount.

The potential for local impoverishment is most clearly seen in the analysis of Duke's entrainment data. The numbers of fish entrained represent a considerable part of the local population. The Duke studies estimate that the proportion of the larval gobies entrained by the power station varied between 21-27%, Longjaw mudsucker 17-50 %, Anchovy complex 7-10%, Silverside about 14% and combtooth blennies about 3%. In the earlier studies, the total loss of eggs and larvae was estimated at about 12% of the total source stock.

Natural populations cannot remain unaffected by extra mortalities of these magnitudes when applied on a continuous basis. The percentage loss for some species is so large that, in our assessment, they can never be considered acceptable. The ETM calculations demonstrate that, for some species, a high proportion of the local fish larvae are entrained and probably killed by the power station. It is well established that such loss rates can impact populations, even of short-lived, high-fecundity species such as gobies.

It is clear that the entrainment and impingement mortality rates observed would not allow isolated populations within San Diego Bay to maintain their size. SBPP is causing the South Bay to act as a trap that kills animals recruited from the ocean beyond. While many of the animals killed are derived from populations that extend beyond the bay, it should be noted that many of the fish killed by the cooling water system are typical members of the San Diego Bay community. Thus it is quite possible that the present cooling water system has reduced the size of the local fish and crustacean population by a significant amount

Duke Study Does Not Adequately Assess Impact to Non-commercial and Non-target Fish

Only a small fraction of the life forms present in a water body are normally given a monetary value. Yet almost all the species present in the water column or living on the river or seabed in the vicinity of an outfall will be impacted by a direct cooled power plant. Most are not fished or sold in any form and are not of immediate value as tourist features, as may be the case for an elephant seal colony or turtle breeding beach. In general somewhere in the region of about 1 in every 100 species can be assigned a monetary value. The question is how should we consider the worth of the other 99%, many of which are small or even microscopic.

The interdependence of species, and the fact that all species can be viewed as interconnected units within a food web, immediately suggests that the economically important species are dependent upon the existence of many other species either directly because they are their food or indirectly because they help to create some aspect of the habitat that is essential for their existence.

Perhaps the most clear cut, but unusual, situation would be where clear dependence can be shown between two species such that a dependent species that has an economic value cannot exist without another supporting species. With this type of situation the supporting species can be assigned a value as a resource base for the economically important species. Given sufficient ecological knowledge it would be possible to calculate how many of the economically important species would be lost if the resource base was diminished in size.

Because almost all the commercially important fish and crustaceans are predators that feed on a variety of prey and can often be quite flexible in their feeding behaviour such a simple relationship will not generally be the case. However, as the vast majority of species with no economic value can be placed towards the foot of the trophic pyramid, they can be viewed collectively as the resource base upon which the economically important species depend.

Such an approach suggests how we might give a value to the majority of species. Suppose that an estuary has 20 species that can be given a commercial value and these 20 have a production of say 50 kg per hectare per year and this is supported by an ecosystem that achieves a maximum annual standing crop of say 50,000 kg per hectare. Then we might roughly state that 1000 kg of standing crop of all species is needed to produce 50 kg of commercially important species. Then if entrainment reduces the standing crop by say 10% we can conservatively assume that this will result in a proportionate reduction in the commercial species of 10%. Once such a rough relationship is established we can then give a monetary value to any loss to the ecosystem.

Some measure of the likely loss of standing crop of plankton can be gained from simple modelling. We can model the plankton community using say a logistic equation such that in the absence of the power plant the population would be at carrying capacity. Then given a daily mortality rate determined by the proportion of the total volume of the habitat that is pumped via the plant the fractional reduction below carrying capacity that results can be estimated.

While the approach outlined above might be used to estimate the overall value of the resource in terms of its food value to economically important species this does not represent the full value of species lost by entrainment and impingement. Unquantifiable losses include the following.

- Loss of recycling efficiency and the loss of nutrients and materials to the local ecosystem. Damage to ecosystems typically results in a loss of ecological efficiency and the release of materials that would have been retained within the ecosystem. Thus a river or estuary may export to the ocean more resources than would have been the case if the ecosystem had been undamaged.
- Power plant mortality will tend to favour short-lived species at the expense of long-lived forms. This tends to produce a bias in favour of more ‘weed-like’ life forms. The naturally occurring species towards the top of the food chain such as striped bass are typically adapted to live in climax ecosystems in which short-lived species are less dominant. Further, the bias produced may result in a loss of biodiversity resulting in a less stable ecosystem.
- Damage and alteration to the ecosystem may allow the invasion of unwelcome aliens. In particular, fasting growing invasive species that have adapted to man-made or disturbed habitats may reach pest levels. It is notable that most of the alien species that have become established in the Hudson estuary for example are invasive ‘weeds’ suggesting that human disturbance may be implicated in allowing them to become established.
- Damage to ecosystems may increase the risk of the development of organisms dangerous to human health. Water bodies receiving heated effluent have been closed to water sports because of the risk of pathogens. Red tides may become more frequent and toxic in highly disturbed and unnatural waters. This can increase the costs associated with environmental monitoring and the processing costs of drinking water.

In addition to the costs that may accrue we can also view the ways in which the ecosystem as a whole can offer us services. Some of the most important are listed below.

- Recycling of human waste. This is probably the most important service that is offered by waters close to human habitation.
- Demobilisation and detoxification of chemical waste products. The living world is involved in both the breakdown and locking away within the sediments of dangerous metals, petroleum products and a vast range of chemical wastes and products.
- The stabilisation and accumulation of sediments. Without vegetation soft sediments would be far more mobile resulting in increased turbidity and sedimentation of channels.
- Support to the terrestrial ecosystem. In many localities there can be a major re-exportation of biomass from water to the land via insects and other invertebrates but also via fishing birds and mammals. Thus the presence of a diverse and rich aquatic fauna can enhance the health of the associated terrestrial flora and fauna.

Finally the presence of rare species, or species naturally at very low numbers, are by nature, overlooked by most impingement and entrainment studies. These studies are usually comparatively short in length, only 1 or 2 years, and usually only sample for short time within that period. At SBPP entrainment was sampled for 24 hours monthly for one year and then bimonthly for the second, while the fish impingement was sampled for 24 hours once every two weeks. The chance, therefore, of catching a rare species that occurs in very densities is very low.

Surplus Production Does Not Discount for Data Showing Loss of Production and High Mortality Rates for Larval Fish

The operation of the SBPP results in a loss of production, either by removal from the system or by organisms living and growing sub-optimally. The Duke studies discount this loss as being surplus production and, as such, conclude that the loss has no effect on the environment. The concept of surplus production is based on the view that the entrained organisms and particularly larval fish were in most cases never going to become adults and that their loss is therefore of no significance. This argument is used to state that the SBPP has no effect on the environment and hence there is no breach of the regulations.

It has long been recognised that man is able to deplete the natural populations of mammals, birds and migratory fish. A generally held view is that a serious decline is usually linked to the harvesting of numbers greater than the population can sustain, but, with suitable restraint, a harvesting level can be found that is sustainable in the long-term. The portion that can be taken without reducing the population is thought of as surplus production.

To some extent the idea has origins in agriculture. Each year a certain proportion of the production must be kept aside as seed for the next year, the rest is the surplus that can be consumed. Until recently the assumed availability of surplus production in wild as well as domestic populations was never given serious scientific scrutiny. By the 19th century it was clear that the eggs and larvae of fish must suffer high mortalities and few of the offspring could ever reach adulthood otherwise they would exhaust the resources upon which they rely. Therefore there was a self-evident surplus.

One reason why the concept of surplus production was widely accepted was that it fitted with the prevailing 19th and early 20th century views of natural selection, the struggle for existence. Many young are produced but only a few will survive, the rest are just victims of the struggle. It should also be remembered that until the 20th century religious beliefs frequently held that the world had been created with a surplus of fruits for man to exploit. This view is still prevalent in some regions.

The important point to note is that when questioning the validity of surplus production we question a long respected paradigm. The basic mistake that many people make is to assume that wild populations can be exploited in similar fashion to domestic plants and animals. They forget that in agricultural practice we assiduously nurture and protect the surplus production, whereas in the wild this would be eroded by natural losses. Furthermore we are unconcerned about the fate of the majority of species in the previously established ecosystem.

The concept of surplus production was first used in fisheries science by Graham in 1935. If fish were to be harvested without a decline in their population there needed to be greater spawning capacity within the population than was required to maintain the population. Given the extremely high fecundities of many fish, where the annual egg production of a single female can range from thousands to millions, this seemed self-evident. Biologists could also point to examples of populations where overcrowding resulted in considerable damage to the reproductive output of the weak or unlucky.

For example, salmon have been observed to destroy redds (nests of eggs buried under the gravel on the stream bed) from earlier spawning in years when numbers of returning fish were high. Another example might be the smothering of herring eggs by the eggs of later arrivals on the spawning grounds. Under such conditions it seemed obvious that some of the adults could be removed without harming the reproductive output of the population.

Note that at the core of the surplus production concept lie assumptions about the importance of the population, rather than individual, and an emphasis on the stability of the natural world. The fate of the individual is unimportant – it does not matter which fish dies or lives provided there is sufficient reproductive capacity left. Secondly, those that favour the concept of surplus production generally argue that the natural variability of the world does not require the surplus production from good years to compensate for the poor years when there may be almost total breeding failure. The fact that surplus production arguments do not take account of environmental variability was one of the key features noted by Boreman (2000) in his critique.

Surplus production would not have developed into a fisheries concept if it had not been for the development of density-dependence theory. This theory was developed as an explanation for the stability and continued existence of natural populations. It was realised in the 1930s that populations would continue to fluctuate unless their survival and birth rates varied with the size of the population. Density-dependence allowed the development of a modified view of surplus production - that it was no longer just the excess young that could not be supported to adulthood produced in any particular year, it could be a larger part of the population providing that those that remained after harvesting could respond by either having a higher fecundity or survival rate. Such arguments were used to justify ever increasing exploitation of marine fish populations. They were also used by power plant operators to defend the destruction of millions of young fish and other aquatic organisms.

The development of fisheries models has been completely anthropocentric. We know of no model that asks what yield we can take that not only protects the population but also avoids harming the natural predators of a fish. It should always be remembered that it is not only the abundance of the prey that can affect a predator but also the size distribution. Almost all predators have a favoured size of food. However, it is clear that the disproportionate harvesting of particular age groups is the norm and will result in a change in the population age structure even if total numbers remain stable.

Thus, if a population can support additional anthropogenic mortality it may still damage the predators. No fish or other biological resource can be harvested at zero cost to the ecosystem. In this sense there cannot be any such thing as surplus production. That the no cost view is commonplace is certainly suggested by the descriptive terms and statements of some who have argued that power plants cannot harm fish populations and natural communities. Goodyear (1977) referred to 'excess production' and Watt (1968) to 'wastage'. Here we see a different viewpoint being introduced. The animals that can be harvested are an excess or natural wastage that, if not killed, would in some way be flushed from the system. Their arguments are based on the premise that the fish killed by impingement and most importantly entrainment are of no worth, either to man or other organisms within their ecosystem. John

Boreman (2000) has, by taking an ecosystem approach, shown the fallacy of this argument.

"If a surplus is being removed by power plant operations, then something else in the ecosystem is being out-competed."

This is an important point that has frequently been lost during studies of density-dependence in fish. The focus of the population modeller tends to be the maintenance of adult numbers within the population under study. No consideration is given to the maintenance of the predators that normally feed upon the fish if man does not take them. Mayers & Worm (2003) discuss the recent large declines in the abundance of top predators including piscivorous fish, mammals and reptiles because of overfishing. They estimated predator levels at only 10% of undisturbed levels.

Density-dependent arguments are concerned with the stability and continued existence of a target population as mortality and natality changes. They can say nothing about the overall ecological health of a system subjected to greatly increased mortality rates from power plants and other cooling water intakes. A core aspect of density-dependent control theory is that the agents of density-dependent control are almost always living organisms. This is because only living entities can respond to the size of the prey population by growing or shrinking in abundance. A change in the response of the controlling species that is proportional to the size of the controlled population is an essential pre-requisite for density-dependent control. This observation brings out clearly the point made by Boreman (2000). If a power plant is killing large numbers of a small fish, say the anchovy, then the animals that would normally control the population by predation or competition will respond to the reduced abundance of anchovy. The predators must decline in abundance or move away while their competitors may increase in numbers as they exploit the vacated space. Thus, the existence of surplus production and density-dependence implies that there are inter-species dependencies and relationships and further implies that these species must respond not only to direct entrainment and impingement losses but also to those of their prey.

The only situation in which the predators and competitors would not express the losses to a prey population would be if the loss were tiny and hidden within the random variation that all populations exhibit.

Hidden within the adult equivalent approach to assessment of power station losses there is also a surplus production argument. Just because only a small number of the young will live to adulthood does not mean that these young over their brief lives might not contribute to the maintenance of predators and other organisms that can take advantage of their presence. The weakness of the adult equivalent argument can be easily seen by analogy. A hundred tons of rice might be required to give sufficient energy to take 5 humans from birth to age 70. However, during a famine this quantity of rice might sustain 2000 people for sufficient time to ensure their survival until the next harvest. If the rice store were to burn down during a famine, who would equate the loss to 5 human equivalents?

The fact that almost all exploited fish populations have declined indicates that the amount of surplus production that can be taken by man may be much less than has frequently been assumed. While the destruction of some populations is easy to understand as a simple uncontrolled scramble for a limited resource, it is disheartening to note that even managed fisheries have collapsed. The reason for this is essentially because we have misunderstood (overestimated?) the amount of density dependent compensation within the population. The history of management failure and the frequently observed strong recovery when fishing pressure or mortality rates are reduced gives clear examples of the exaggerated density-dependent response. A good example is the striped bass in the River Hudson. It was argued in the 1970s and early 1980s that the population was under density-dependent control and thus reduced mortality would not allow the population to increase. It was effectively saturating its environment. Yet the closure of this fishery resulted in a 15-fold increase in abundance.

In conclusion, the only theoretical basis for surplus production is the observation that some populations in some years produce an excess of young that cannot hope to survive. These young can be harvested without affecting the size of the adult population. A key aspect that surplus production arguments never consider is the between-year variation in survival and thus production. Some fish may depend on occasional highly favourable years when they can produce so many young that they saturate the appetites of the predators and create a strong cohort that will sustain the population for many years. An example of such a fish is the striped bass. Further, harvesting may result in the exclusion of some predators from the resource. The weakness of surplus production pleading can be exposed by the following arguments:

1. Despite the outward appearance of stability in the marine and freshwater environment, fish live in highly variable environments and this is not considered in the models. When variability is introduced into models the predicted surplus production is often much reduced or non-existent.
2. Surplus production only exists in a model that includes man and the target population. When we harvest, the natural predators are, to some extent, denied a food resource.
3. A high proportion of exploited populations are much reduced or in decline. Any reduced survival in these populations must be reflected in reduced adult numbers.
4. The existence of density-dependent control does not imply that there must be surplus production as is often assumed. We must separate the two concepts or we will find ourselves arguing against the established scientific paradigm. Density-dependent control comes about because species are held within a matrix of active and potential controls based on their predators, prey, parasites and diseases. This network of interactions is maintained in part by the consumption of the focal species. If we take a harvest then this control network is disrupted. Thus our harvesting does to some extent break the very density-dependent relationships that the proponents of surplus production claim. The end result of anthropogenic mortality is known, it is ecological degradation.

Another Fallacy of the Theory of Surplus Production – What Feeds on Larval Fish?

The concept of surplus production is based on the view that the entrained organisms and particularly larval fish were in most cases never going to become adults and that their loss is therefore of no significance. This will not be the case if their loss denies other organisms this food resource. Below we consider what organisms feed on larval and small fish. Many organisms feed on larval fish and eggs. Some species actively seek out larval fish while others are indiscriminate feeders that take them as part of their general diet.

Planktiverous fish such as the clupeids (anchovy, alewife, shad) filter food from the water as they pass through. Some of these species simply filter everything in a certain size range. In others there is evidence that they can discriminate as to which of the small organisms they will take. Filter feeders will generally predate in approximate proportion to the density of the food in the water. Alewife, for example, have been found to have selected larval fish and eggs in their diet as juveniles as they grow they become more omnivorous. The Bay anchovy, an abundant fish in the Hudson, has also been found to feed on larval fish. It is a regular but minor part of their diet (Fish and Wildlife Service, 1989).

Small white perch feed almost exclusively on fish eggs at times when eggs are abundant in the water. (Fish of the Great Lakes, Wisconsin Sea Grant). This indicates that they are actively predating this food resource. The diet of young of year striped Bass (*Morone saxatilis*) was studied in the Hudson between 1993 and 1997 (Hurst and Conover, 2001). It was found to comprise between 2 to 8 % fish. These are likely to include larval fish and eggs. Small predatory fish will take eggs and larvae in large numbers. Species such as stickleback are voracious predators on plankton.

Other groups of organisms also eat larval fish and. Jellyfish, for example, have been observed to feed extensively on larval fish and eggs. In a study in Chesapeake bay Rilling and Houde (1999) noted that ctenophores, a type of small jellyfish, were voracious predators of larval and egg of the bay anchovy: -

> *"Results of mesocosm experiments (Cowan and Houde, 1993) have indicated that up to 20–40% of bay anchovy eggs and larvae in Chesapeake Bay during the peak spawning season may be consumed daily by jellyfish. Purcell et al. (1994) analyzed jellyfish gut contents and estimated that these predators could account for up to 21% of the daily egg mortality and 41% of the larval mortality of bay anchovy in Chesapeake Bay. In site-specific studies, Dorsey et al. (1996) estimated that jellyfish accounted for 0–35%/d of egg mortality, and from 0 to 15%/d of yolksac larval mortality."*

To give some indication of the wide range of animals that will feed on the eggs and larvae of fish we reproduce below the results of a major study on predation on the Grand Banks (Madin *et al.,* 1999) (Table 1). Many of these organisms, or closely related forms will occur in the region. In a study investigating the predation mortality of a wide range of marine animals Madin *et al* (1999) found that many organisms feed on larval fish. Table 1 show a reduced version of their table showing only the species and groups where larval fish or eggs were mentioned.

Table 1 Predator Occurrence Prey Feeding Data (modified from Madin *et al* 1999)

Cnidarians	Hydroid/ jellyfish		
Clytia gracilis (hydroids)	Often very abundant on crest	Nauplii, Copepods, Fish larvae	F, T responses, selectivity on copepod eggs & nauplii, rates on cod larvae (GLOBEC data)
Cyanea capillata	Patchy occurrence	Copepods, Fish eggs	Rates, selectivity on copepods (literature data)
Other hydromedusae	Variable occurrence, rarely dense	Copepods, Fish larvae	Rates on fish larvae from gut contents, experiments (literature data)
Ctenophores	Jellyfish		
Bolinopsis infundibulum	Patchily abundant on flank, hard to quantify	Copepods, Fish larvae	Rates on copepods from gut contents (GLOBEC data)
Pleurobrachia pileus	Patchily abundant in spring	Copepods Fish larvae	Rates on copepods from gut contents (GLOBEC data), F and T responses (literature data)
Euphausiids	Crustacean		
Euphausii krohnii	Patchily abundant	Copepods Fish larvae	Estimate from other species (literature data)
Isopods	Crustacean		
Cirolana polita	Demersal, in water column at night	Copepods, Larval fish?	Rates on nauplii, copepods from experiments (GLOBEC data)
Fishes			
Clupea harengus	Briefly abundant during migratory passage	Copepods, larval fish	Rates on copepods, fish larvae from gut contents (COP-GLOBEC data),
Scomber scombrus	Briefly abundant during migratory passage	Copepods, larval fish	Rates on copepods, fish larvae from gut contents (COP-GLOBEC data),

As can be seen from this table several species of hydroid, crustacean, jellyfish and fish were observed to feed on larval fish and eggs.
No assessment was made in the 316 studies of any interactions resulting from the loss of entrained organisms.

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RECOMMENDED OPTIONS FOR MAXIMUM WATER TEMPERATURE LIMITS AND MINIMUM DISSOLVED OXYGEN LIMITS AT A COMPLIANCE POINT FOR DISCHARGES FROM THE SOUTH BAY POWER PLANT IN SAN DIEGO BAY, NECESSARY TO PROTECT BENEFICAL USES

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San Diego Audubon Society
Sierra Club, San Diego Chapter
Surfrider Foundation, San Diego Chapter

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INTRODUCTION

The purpose of this report is to evaluate and recommend two options for maximum temperature limits and minimum dissolved oxygen limits at a compliance point for discharges of thermal effluent from the South Bay Power Plant (SBPP), necessary to protect beneficial uses. Documentation for these recommendations is based in part on evidence from past temperature and dissolved oxygen measurements and biological field studies conducted to evaluate the ecological effects of thermal effluent from the SBPP on the adjacent marine environment of inner San Diego Bay. This documentation also is based on information from species-specific laboratory and field studies concerning temperature and dissolved oxygen tolerances of marine invertebrate and fish species that inhabit the inner Bay. Section 316(a) of the Clean Water Act (CWA) requires that States impose an effluent limitation with respect to the thermal component of a discharge, taking into account the interaction of this thermal component with other pollutants, that will assure the protection and propagation of balanced, indigenous populations of shellfish, fish, and wildlife in the receiving water. In 1972-73 a seasonal thermal effects study (Ford & Chambers 1973, 1974) was completed for the discharger, San Diego Gas & Electric Company, to investigate compliance with the State Thermal Plan and CWA Section 316(a). Evidence from both intertidal and subtidal sampling indicated that elevated water temperatures caused by the thermal effluent had adverse impacts to bay organisms that inhabited the discharge channel, particularly during late summer and early fall months. These effects were reduced during the winter and spring periods when ambient water temperatures and the temperatures of the thermal plume were lower. During all seasons, however, major adverse effects appeared to be confined to the discharge channel. The overall conclusion of these studies was that the thermal effluent from the SBPP had no major adverse effects on the benthic communities beyond the outer end of the discharge channel. Subsequent thermal effects studies and monitoring were conducted during the summer months by several research entities (See, for example, summary reports by Lockheed, 1981 and E.A. Engineering, Science, and Technology 1995). These later studies confirmed the general conclusions of Ford & Chambers (1973, 1974). However, all of these studies have occurred since the plant has been in operation. Because of this, no pre-operational baseline studies of the South Bay have been possible.

While the permitted thermal limits in effect at the time the previous 316(a) studies were conducted have not changed, the compliance point used for verification of compliance with those thermal limits was relocated in Order No 96-05 issued by the San Diego Regional Water Quality Control Board. An earthen dike extends from the northern side of the SBPP discharge basin into San Diego Bay, separating the inlet and discharge channels (Figure 1). The width of the SBPP discharge channel (cooling water channel) varies from approximately 100 feet at the Plant property line to approximately 1,200 feet at its widest point in the Bay. The length of the discharge channel is approximately 5,200 feet. The thermal limit compliance point in the 1970's through 1995 was located at the outer end of the dike separating the inlet and discharge channels (Figure 1). This point was approximately 5,000 feet downstream from SBPP property line. The designated compliance point for the thermal limits in the current NPDES permit is approximately 1,000 feet downstream of the SBPP property line (Figure 1). The earlier compliance point established was, therefore, approximately 4000 feet downstream of the current compliance point. This effectively provided a large dilution zone, allowing the SBPP to discharge more heat in thermal effluent to the cooling water channel than is possible in applying the current compliance location 1000 feet downstream from the property line of the SBPP.

Described in subsequent sections of this document are the lines of evidence employed to develop specific recommendations for establishing maximum water temperature limits and minimum dissolved oxygen limits at a point of compliance that can be expected to protect beneficial uses. Because issues concerning water temperature and dissolved oxygen are closely related, in some cases they are considered together.

TEMPERATURE AND DISSOLVED OXYGEN LIMITS: EVIDENCE FROM FIELD STUDIES

Evidence from Ecological Field Monitoring Studies 1968-1994

Introduction

In the summer of 1960 the San Diego Gas & Electric Company began operation of a major fossil fuel steam generation plant near the inner end of San Diego Bay, at an approximate axial distance of 14 miles from the bay entrance. A second generating unit was added to the system in the summer of 1962 and a third in the summer of 1964. A larger, fourth unit was placed in commercial service in August 1971. Water is drawn from the bay and the thermal effluent returned by way of a shallow discharge channel that is set off from the bay by an earthen dike (Figure 1). Prior to the addition of Generating Unit 4, the maximum extent of the thermal discharge was confined to a radius of approximately 1500-2000 yards (4500 – 6000 feet) from the outer end of the discharge channel, with that extent varying markedly both seasonally and in relation to the tidal cycle, as well as in relation to the generating units that are operating (A.S. DeWeese, South Bay Temperature Survey, Jun 9, 1965, SDG&C File NO. EPG 420, and Ford & Chambers1974). In 1973, the maximum extent of the thermal plume with all four generating units in operation was approximately 3000 yards or 9000 feet (Chambers & Chambers 1973, Ford & Chambers 1974).

Early Monitoring Studies

Early monitoring studies of the South Bay Power Plant (Ford, 1968, Ford et al 1960, 1971, 1972) provided comprehensive information about physical and biological conditions in South San Diego Bay, including particularly the nature of the thermal discharge prior to and immediately following the addition of Generating Unit 4, and the effects of this thermal effluent on marine life during the late summer and early spring months. These initial studies included quantitative sampling of intertidal and subtidal benthic algae and invertebrates, fishes, plankton, and other organisms.

Seasonal Monitoring Study of 1972-1973

A more comprehensive, quarterly seasonal monitoring study was conducted during 1972-1973 by Ford and Chambers (1973, 1974). The quarterly sampling was initiated in September 1972 and completed in July 1973. The primary purposes of this study were: 1) to provide additional specific baseline information on hydrographic and ecological conditions of the existing aquatic environment in South San Diego Bay on a seasonal basis, using standard methods established in the 1968 study (Ford, 1968); and 2) to assess the ecological effects of the thermal effluent on marine life and other beneficial uses through consideration of species composition, number and diversity of species, and the distribution, abundance, size and biomass of invertebrates and plants taken in grab and core samples.

Information was not obtained in the 1972-1973 study on fishes, aquatic birds, or plankton. Instead, the investigation was limited to species of benthic plants and invertebrate animals that could be sampled adequately by a large-volume grab. This was done because evidence from the 1968 and subsequent studies demonstrated that these species are the best and most easily evaluated indicators of thermal effluent effects. A primary reason for this is that they remain in the same location within or outside the thermal plume.

Eighteen subtidal stations for biological and hydrographic sampling were employed in the South San Diego Bay area, as shown in Figure 2. These were located in a pattern which allowed representative sampling of: 1) the area directly influenced by major segments of the cooling water plume from the South Bay Power Plant; 2: the general area of the power plant cooling water intake; and 3) adjacent control areas outside the direct influence of the thermal plume.

Standardized quantitative methods of biological, physical, and chemical sampling developed in the earlier studies were employed at these 18 subtidal stations during the period September – July, and at seven intertidal stations during the period September – April. Benthic algae and invertebrates were sampled quantitatively using replicate grab samples subtidally, and by means of replicate core samples in the intertidal mud flat zone. At each station repeated measurements were made of surface and bottom water temperatures, sediment temperatures, dissolved oxygen concentrations, salinities, sediment organic content, sediment grain size distributions, and other physical-chemical characteristics at each station, as described by Ford and Chambers (1973, 1974). It is important to note that this ecological monitoring study for the South Bay Power Plant remains the only one ever conducted on a full seasonal basis, making it particularly valuable in helping to establish ecologically meaningful temperature and dissolved oxygen limits for the current 1000 foot compliance point. The seasonal data obtained in this 1972 – 1973 study for water and sediment temperatures are summarized in Figures 3 & 4 and for dissolved oxygen in Figure 5.

Results and Conclusions of 1972-1973 Monitoring Study

The results obtained suggest that the species composition of benthic plant and invertebrate associations remained moderately stable throughout the year in South San Diego Bay, although there were some evident seasonal changes. In general, numbers of species and densities were lowest during the warm water conditions of late summer-fall.

As in previous studies conducted in the South Bay, evidence obtained from both subtidal and intertidal sampling during 1972-1973 suggested that high temperatures caused by the thermal discharge in the late summer-fall, and to a lesser extent in July, had adverse effects on the numbers, diversity, and abundance of many groups of species within the cooling channel itself (Stations E5, E7, and F4). However, these effects were much less obvious during the winter and spring periods when both ambient water temperatures and those within the thermal discharge pattern were lower. Much the same general pattern appeared to hold for both the intertidal and subtidal areas, which also share a majority of their species in common. During all seasonal periods, the most severe adverse effects appeared to be confined primarily to the inner portion of the cooling channel.

Mean bottom water temperatures measured at Station F4, F3 (outer end of cooling water channel) and other sites for one month periods prior to biological sampling are shown in Figure 3. At Station F4, these temperatures were highest in July (84.6ºF), next highest in September-October (82.0ºF), substantially lower in March-April (73.4ºF), and lowest in the winter months of December-January (68.1ºF). Mean sediment temperatures (Figure 4) were nearly the same in all cases. Mean dissolved oxygen concentrations measured at the time of biological sampling at Station F4 and other sites are shown in Figure 5. At Station F4, these means were lowest in April and September-October (6.2 and 6.7 mg/L) and highest in January (7.3 mg/L).

However, as shown in Figure 3, mean bottom water temperatures were considerably higher in the cooling water channel, ranging from 66.8ºF in December-January 1972-1973 to 88.3ºF in September-October 1973 at Station E5 (Figure 3). Mean sediment temperatures at Station E5 showed a similar trend, ranging from 70.9ºF and 70.0ºF in January and April to 88.0ºF in September-October (Figure 4). Mean dissolved oxygen concentrations at Station E5 in the cooling water channel also showed a wider range of values, from 5.2 mg/L in July to 8.0 mg/L in September-October (Figure 5).

The results of statistical comparisons between the control and outer discharge pattern areas suggested that during the late September-October period of 1972, and to a lesser extent in July 1973, this portion of the thermal plume just beyond the end of the cooling channel (Station F4) apparently had some adverse effects on the infaunal invertebrates found there. This was reflected by lower numbers of invertebrate species, involving primarily polychaetes and crustaceans, and a lower number of species and of species and taxa diversity for all invertebrates combined (Ford and Chambers 1973, 1974). The trends in these values and associated trends in distribution and abundance were obvious within the station pattern. They suggested that the adverse effects detected by these tests were confined primarily to stations in the thermal effluent flow beyond the end of the cooling channel. However, most of these differences were relatively small, suggesting that the adverse effects apparently were not as severe as those observed within the discharge channel. However, it is important to recognize that they reflected an already artificially heated environment. The individual species involved were identified and their patterns of distribution and abundance described (Ford and Chambers 1974).

In contrast, the numbers of algal species forming the plant mat on the bottom were significantly greater within the outer discharge area then in the control area during this same period. If this represents a true difference, then it may suggest that thermal conditions for plants during this period were somewhat more stimulating to plant growth within the outer portion of the thermal plume than they were beyond it. This may be interpreted as a possible disturbance of the natural benthic community by the thermal plume.

There were no statistically significant differences for numbers and diversity of species between the outer discharge and control areas in either January or April 1973. This suggested strongly that most of the adverse effects described above were confined o to the summer and early fall period of higher ambient and effluent water temperatures. During the cooler winter and spring periods, no such adverse effects on the number or diversity of species apparently occurred.

As in the pre-1972 studies (Ford 1968, Ford et al 1970, 1971, 1972), diversity of taxa and abundances for several invertebrate groups sampled during the September-October and January periods showed significant inverse (negative) correlations with sediment and water temperatures (Ford & Chambers 1973, l974). The number of individual groups that showed this correlation was reduced during the January and April sampling periods of lower water temperatures. However, as for the earlier periods, the total number of invertebrate species continued to show these inverse correlations with water temperature. These correlation results further indicated that, with the exception of sediment temperatures, no other physical factors considered had significant relationships to number and diversity of species, and abundance of the kind shown for these effluent temperature characteristics. This confirmed that there was, in fact, a meaningful temperature effect on these biological characteristics, rather than one involving some other physical variable separately or in parallel with temperature. The fact that sediment grain size and chemical characteristics were relatively uniform throughout the study area probably explains why there were few significant correlations with these physical variables. Dissolved oxygen concentrations showed no significant correlations with these biological characteristics. This is not surprising, because they showed little seasonal variation except those measured within the cooling water channel (Figure 5).

As in the pre-1972 studies, these significant inverse correlations with temperature indicated that higher sediment and water temperatures induced by the cooling water effluent had adverse effects on several major groups of benthic invertebrates by reducing the number and diversity of species and, in some cases, their abundances at a given location. The statistical comparisons among station groups, discussed earlier, indicated that these adverse effects were restricted primarily to the area within the cooling channel and that they varied seasonally. In contrast, the abundances of some major groups showed significant direct correlations with temperature.

The results of statistical comparisons suggested very strongly that there were no significant adverse effects of the thermal plume on the biomass of nearly all major groups of organisms inhabiting the outer discharge pattern area beyond the end of the cooling channel. Only the biomass values of decapod crustaceans and gastropod mollusks were significantly lower in the outer discharge area than at the control stations in July 1973. This generalization applied for all of the four seasonal sampling period. In fact, the opposite appeared to be true during the winter and spring because, in all cases where there was a significant difference, the biomass values in question were greater in the outer discharge area than in the control area. The individual groups that showed this difference besides benthic plants were cnidarians (coelenterates), ostracods, gastropod molluscs, and the brittle star *Amphipholis pugetana*. Two other major groups, the polychaete worms and bivalve molluscs, did not show this difference although they exhibited the same trend. The specific patterns involved in these differences and trends were described for major invertebrate groups by Ford and Chambers (1974).

Given that the control and outer discharge area thermal plume stations were similar in characteristics other than temperature, then the results concerning biomass could legitimately be interpreted as a disturbance effect of the thermal plume on these groups of species and the benthic community.

This effect definitely was related to temperature conditions within the thermal plume. It was not pronounced during the winter and spring periods of low ambient water temperatures. The most probable cause of these higher biomass values is the effect of higher temperatures in producing faster growth rates of the organisms involved. Other possible alternative or additional explanations for both the biomass and abundance effects include enhanced reproductive success and, less likely, the attraction of some species to warm water and their concentration there.

The biomass values for several major groups showed significant direct correlations with temperatures during each of the quarterly sampling periods (Ford and Chambers 1974). This was most pronounced during the spring (March-April) period.

The results of similar comparisons between station groups suggested that, as in the case of numbers and diversity of species, the biomass of many major groups was lower within the cooling channel than in the control area, undoubtedly because of high thermal effluent temperatures present there.

Comparison of data between the summers of 1968-1970 and winter-early spring 1971 (Ford 1968, Ford et al 1970, 1971, 1972) indicated that the biomass of the plant mat on the sediment was markedly reduced and its condition poor during the latter period.

Many of the changes in species composition, distribution, and abundance of small bottom fishes and invertebrates dependent upon the mat, which were observed between these two periods, probably were related to its decline.

This apparently was caused in part by seasonal lowering of water temperatures, a natural effect that is quite accentuated in South San Diego Bay. In addition, because it is a shallow area of silty sediment and much particulate matter, the area experiences high water turbidity during windy periods in the winter and spring as the result of wind wave action. This undoubtedly caused a marked reduction in the light available to benthic plants and probably contributed to the decline of the plant mat. This impact could be further augmented by the turbidity resulting directly from the power plant discharge.

A comparison of total mean biomass values for benthic plants within the station pattern suggested that these data showed somewhat greater variation among stations during 1972-1973 than during 1968 and 1971 (Ford & Chambers 1974). Statistical analysis used to determine if plant biomass differed significantly between the September-October, January, April and July sampling periods of 1972-1973 showed a significant difference attributable to lower values in July 1973. This suggested that the type of major seasonal change in the mat observed in 1968-1971 had not occurred during 1972-1973. Without additional, specific information on water turbidity and other factors, it would be difficult to assess the cause of this apparent difference between years. However, it is quite likely that seasonal changes in the plant mat vary from year to year.

In general, the intertidal algae and invertebrates showed trends that paralleled those of the very similar subtidal species assemblage. Analysis of the intertidal data was hampered because of the very limited numbers of stations and their placement. The difficulty of obtaining an adequate group of representative samples from this habitat because of the soft, cohesive nature of the sediment further compounded the problem. For these reasons, intertidal sampling was not continued beyond the April 1973 sampling period.

Statistical comparisons between 1968, 1972, and 1973, involving numbers of plant and invertebrate species, invertebrate species diversity, and biomass values for these groups obtained during July-October, suggested that these characteristics remained relatively stable over this five year period. This, in turn, provided general evidence that changes in the characteristics of the thermal discharge associated with the addition of Generating Unit 4 at the South Bay Power Plant had not resulted in major shifts in the numbers, diversity, or standing crop of plant and invertebrate species that form major components of the subtidal community.

General Conclusions of the 1972-1973 Monitoring Studies

There are several general conclusions that can be drawn from this evidence. The results of the seasonal monitoring study in 1972-1973 showed that thermal effluent from the South Bay Power Plant had some adverse effects on benthic invertebrates in the area, but that these were restricted primarily to the cooling channel area and to warmer periods of the year (Ford & Chambers 1974). Some effects of the thermal plume that could be interpreted as disturbances to the benthic community also were demonstrated. Thermal effluent from the South Bay Power Plant had no evident, major adverse effects on the benthic invertebrate assemblages beyond the end of the discharge channel during the period September 1972-July 1973.

NPDES Ecological Monitoring Studies of 1977-1994

Following a three-year hiatus in sampling, long-term receiving water and ecological monitoring studies of more limited scope were begun in 1977. This 18-year program was established as a condition of San Diego Gas & Electric Company's NPDES Permit for operation of the South Bay Power Plant. The studies were conducted once each year during the period 1977-1994, in compliance with California Regional Water Quality Control Board Permit No. CA A001368-San Diego Region. These studies involved sampling of benthic invertebrates and an array of physical and chemical parameters at 11 subtidal stations (Figure 6). The locations of the sampling stations were similar in position to 11 of the 18 sites (Figure 2) sampled during previous studies (Ford & Chambers 1973, 1974). Station placement was designed to allow representative sampling of; 1) the area most directly influenced by thermal effluent (the cooling water channel of the SBPP); 2) an area away from the effects of the highest effluent temperatures but still within the elevated temperature field; and 3) an area judged to be outside the influence of the thermal plume. As reported by E.A. Engineering, Science and Technology (1995), SDG&E and its scientific contractors submitted annual reports to the California RWQCB, San Diego Region on the results of these studies. Those reports were as follows:

The citations for each of these annual monitoring documents appear in the References section of this report.

A major summary report prepared by Lockheed Environmental Sciences (1980a) provided more detailed syntheses and evaluations of the data obtained during the first four years of these NPDES studies. Data obtained during the entire 18-year study period were similarly synthesized and evaluated in detail by E.A. Engineering, Science, and Technology (1995).

This 18-year receiving water and ecological monitoring program focused on the evaluating possible influences of thermal effluent from the SBPP on physical and chemical characteristics and benthic infauna in the South Bay during the late summer period. This focus on the invertebrate infauna had its origin in the studies of all the benthic categories (plankton, periphyton, fishes, and benthos) by Ford (1968). Based on the results from those studies, Ford (1968) and Ford & Chambers (1974) concluded that the infaunal assemblages were the best and most reliable indicator of responses to changes in the environment. These include sediment and water temperatures, dissolved oxygen, salinity, and organic carbon, and nitrogen concentrations in the sediment. The choice of the summer season was based on the decision that the combined effect of higher natural ambient temperatures present during the summer and higher thermal effluent temperatures at that time were likely to be most stressful of the year to the infauna and other species assemblages.

To some extent, the results reported by Ford and Chambers (1973, 1974) also supported a focus of this long-term monitoring program on the late summer period. They reported "that the species composition of benthic plant and invertebrate associations remained moderately stable throughout the year…although there were some evident seasonal changes. In general, numbers of species and densities were lowest during the warm water conditions of late summer-fall." Ford and Chambers (1973, 1974) further reported that their studies, …"suggest that high temperatures caused by the thermal discharge in the late summer-fall, and to a lesser extent in July, had adverse effects on the number, diversity, and abundance of many groups of species within the cooling channel itself (Stations E5, E7, and F4). Importantly, however, these effects were much less obvious during the winter and spring periods when both ambient water temperatures and those within the thermal discharge were lower. Much the same general pattern appeared to hold for both the intertidal and subtidal areas, which also share a majority of their species in common…During all seasonal periods, the adverse effects appeared to be confined primarily to the inner portion of the cooling channel." In addition, they noted "there were no statistically significant differences for numbers and diversity of species between the outer discharge and control areas in either January or April 1973. This suggested strongly that the adverse effects…were confined only to the summer and early fall period of high ambient and effluent water temperatures." Obviously, the chief disadvantage of sampling only during the summer is that important seasonal differences in the effects of the thermal effluent were missed.

Results and Conclusions of the 1977-1994 NPDES Monitoring Studies

The yearly reports from this NPDES monitoring program all focused on evaluating whether or not there were differences among sampling stations in water temperatures and physical and chemical characteristics of the bottom sediment, and in ecological features of the infauna. Differences among stations were observed in the form of gradients from Stations E7 and E5 within the cooling water channel of the SBPP at the inner end of the Bay, bayward toward the far-field plume (Stations C3 and A3) and the control site (Station N2). These station locations are shown in Figure 6. Most notably, there were consistent gradients with distance from the cooling water channel. These included the obvious gradients of decreasing sediment and water temperatures, together with decreasing percent silt and clay fractions in the bottom sediment, as well as increasing dissolved oxygen concentrations and water transparency (LES 1980a, EAEST 1995).

The results of monitoring during the18-year period 1977-1994 (EAEST 1995) led to many of the same conclusions as those of the 1968-1973 studies (Ford 1968, Ford & Chambers 1974). The 1977-1994 studies showed that during the summer, diversity of species and taxa, abundance (densities) and, to some extent, the biomass of the infauna at stations within the cooling water channel were lower than those within the near-field thermal plume beyond the end of the dike and those at far-field sampling stations. These differences were attributed primarily to temperature effects of the thermal effluent. The results further indicated that there were few such evident adverse effects on the infauna beyond the outer end of the cooling water channel (Stations F3 and F4, Figures 2 and 6). Also in common with the results of the 1968-1973 studies, these studies in 1977-1994 suggested that the increases in water temperature by thermal effluent in the near-field area outside the cooling channel produced at least moderately higher biomass of infaunal groups. These elevated biomass values may represent a disturbance modification effect on the infauna due to increased growth and reproduction.

Both the individual contractors for the 1977-1994 studies and the four year synthesis by LES (1980a) employed multiple regression analyses in an effort to determine which of the physical and chemical gradients were most strongly related to infauna characteristics of diversity, numerical abundance, and biomass. Generally, the reported inverse correlations were strongest with increased percent silt and clay, with increased water and sediment temperatures, and with COD and TKN in the sediment. Strongest direct correlations were with increased amounts of algae and plant detritus. The studies concluded that percent of silt/clay in the sediment was the principal factor regulating infaunal community structure, as secondarily modified by water and sediment temperatures. Both sediment grain size and temperature were significant factors within the cooling channel. However, multiple regression analyses were not capable of separating the relative influence of sediment grain size versus temperature within that channel (EAEST 1995).

From their 18 year synthesis, E.A. Engineering Science, and Technology (1995) reported that there were the expected year-to-year variations within sampling stations for all parameters, but that at a given station there were no appreciable long-term trends upward or downward among important factors such as water temperature, sediment temperature, COD, TKN, grain size characteristics, dissolved oxygen, salinity, or transparency. A slight trend downward in water and sediment temperatures at the discharge cooling channel stations was evident from the 1970s into the 1980s.

EAEST (1995) also reported on the gradients in physical, chemical, and certain of the invertebrate infaunal characteristics from the inner end of the Bay northward toward the far-field and control sampling stations that also were evident in the yearly set of data. They found that the gradients in infaunal characteristics noted in the yearly studies also were evident from overall analyses of the 18-year data set, especially for infaunal diversity, number of species and taxa, and to a lesser extent for the total abundance of benthic invertebrates. However, there was little evidence for the gradient of increased infaunl biomass from the cooling channel stations bayward toward the far-field and control stations, as reported in the earlier studies. However, it should be noted that these data for 1977-1994 were all from the summer. As a result, the lack of seasonal data may have masked evidence of such gradients in biomass of the infauna. EAEST (1995) reported that their evaluation of the 18-year data set supports the major conclusions from the previous studies: 1) that the species composition, mean diversity, and mean densities of the infauna were lower within the cooling water channel than at the near-field, far-field, and control sampling stations; and 2) that those lower values probably were related to the combined effects of thermal effluent from the SBPP and the natural physical characteristics of the inner Bay. They reported that there were few, if any, adverse effects on the infauna outside of the cooling channel.

E.A. Engineering, Science & Technology (1995) noted that the cooling water flow of Generating Unit 4 represents 33 percent of the total flow at the SBPP, and that the size of the thermal plume is also approximately one-third smaller when Unit 4 is not operating. The smaller thermal plume was directly reflected by a general downward trend in summer water and sediment temperatures observed at the near-field and discharge cooling channel sampling stations when Unit 4 was not on line. This is a particularly important point, because it emphasizes the very direct effects that the number of generating units in operation at a given time, and the cooling water requirements of each unit, have on the temperature characteristics and extent of the thermal plume. During the current energy crisis, it is likely that all four generating units of the SBPP will be used to a greater extent, leading to a correspondingly greater thermal loading in the plume. This will tend to accentuate effects on marine organisms in the cooling water channel and possibly in adjacent areas of inner San Diego Bay.

In common with the conclusions from earlier studies (Ford 1968; Ford and Chambers 1973, 1974; Michael Brandman Associates 1990), analysis of the 18-year data set indicated that the physical and chemical characteristics and infauna of San Diego Bay are similar to those of other bays along the California coast. A general conclusion reported by E.A. Engineering, Science & Technology (1995) was that the species composition, relative abundance, and total abundance of the infauna in the study area remained very similar in 1994 to those determined in 1977. They concluded further that most of the environmental conditions monitored did not show any appreciable long-term changes. Similarly, information concerning marine species of inner San Diego Bay as a whole suggests that the species composition, relative abundances, and biomass of the infauna the fish fauna, and other species assemblages remained very much the same over the 21-year period 1968-1989 (Michael Brandman Associates 1990).

Evidence From NPDES and Other Water Column Monitoring Studies 1996-Present

Based on the review of the 18-year monitoring program described in the preceding section, the San Diego Regional Water Quality Control Board determined that further monitoring of the sediment and invertebrate infauna was unnecessary at that time. Accordingly, the Board amended the permit requirements. For the amended program, temperature, dissolved oxygen concentrations, salinity and light extinction in the water column have been sampled monthly on a continuing basis.

These continuing monitoring studies have been and are now conducted by MEC Analytical Systems, Inc. (See, for example, MEC 1997, 2001). Prior to April 1999, the monthly reports were submitted to the Regional Board on behalf of the San Diego Gas & Electric Company. On April 23, 1999, Duke Energy Power Services assumed operating responsibilities for the South Bay Power Plant, and the monthly monitoring reports are now submitted to the Regional Board on behalf of that discharger.

MEC has continued to employ the same 11 receiving water stations (Figure 6) used in the more extensive monitoring of 1972-1994. Measurements have been made monthly at each of the 11 stations for air and water temperatures, dissolved oxygen concentrations, salinities, and water transparency, primarily by employing a scanning data logger (MEC 2001). Except for air temperature and transparency, the measurements have been made at 2-3 foot depth intervals through the water column.

These monitoring reports by MEC provide a very representative, recent data set that is useful in establishing temperature and dissolved oxygen limits for the 1000 ft compliance point in the cooling water channel of South Bay Power Plant. Their specific use is considered in the following subsection and in final section of this report entitled Recommendations.

Applied Science Associates (1998) conducted an evaluation of dissolved oxygen concentrations and associated biological and hydrographic processes in South San Diego Bay. This report included as its primary goal the formulation of a proposed water quality objective for dissolved oxygen in South San Diego Bay, as requested by the San Diego Regional Water Quality Control Board and the San Diego Gas & Electric Company.

Other than the diurnal and other changes in dissolved oxygen concentrations measured and described, the contents of this report are substandard in most respects. Most disappointing of all is the water quality objective for dissolved oxygen proposed by Applied Science Associates (1998). Their report concluded:

> "Accordingly, the following narrative water quality objective for South San Diego Bay is proposed:

The dissolved oxygen concentrations of South San Diego Bay shall not be depressed to levels that adversely affect beneficial uses as a result of controllable water quality factors.

By definition, this water quality objective is protective of the beneficial uses of South San Diego Bay from the potential adverse effects of low dissolved oxygen resulting from other than naturally occurring events. Analysis of available information demonstrates that all designated beneficial uses of the Bay are being protected here and hence this proposed water quality objective for dissolved oxygen is currently being achieved."

This is a very poor water quality objective for several reasons. It is far too vague. Compliance with it would be almost impossible to validate. Without truly comprehensive ecological studies, how can one demonstrate that no beneficial uses of the inner bay, including those of estuarine invertebrate and fish populations, have been adversely affected by low dissolved oxygen levels associated with the thermal plume? In addition there is no real proof or "demonstration" of the justification statement in the last sentence quoted above. This is particularly true for the area within the cooling water channel, where beneficial uses involving estuarine animals are adversely affected by both increased temperatures and correspondingly reduced dissolved oxygen concentrations.

In any case, this general and vague narrative water quality objective has no real practical value as it might apply to a compliance point in the discharge channel of the South Bay Power Plant. Numeric water quality limits for dissolved oxygen concentrations must be used instead. The existing Basin Plan water quality objectives is entirely appropriate to inner San Diego Bay from an ecological standpoint. It states: "Dissolved oxygen levels shall not be less than 5.0 mg/L in inland surface waters with designated MAR or WARM beneficial uses. The annual mean dissolved oxygen concentration shall not be less that 7 mg/L more that 10% of the time." This scientifically valid objective must be met in operating the South Bay Power Plant.

Conclusions from the Field Monitoring Studies as they Apply to Setting Temperature and Dissolved Oxygen Limits at the Compliance Point

The results from the ecological monitoring studies of 1968-1994, as described in preceding sections, all point to the same conclusion. It is that most adverse ecological effects produced by thermal effluent from the South Bay Power Plant are restricted primarily to the area of the discharge channel (Figures 1 & 6). This suggests that water temperatures and dissolved oxygen concentrations measured at Station F3 (Figure 6), located just beyond the end of the cooling water channel, might be the most pertinent values to employ in setting maximum water temperature and minimum dissolved oxygen concentration limits for the compliance point. Station F3 might be the logical choice because it is located just beyond the downstream end of the cooling water channel in an area where few adverse effects on the invertebrate infauna were detected in the studies of

1968 – 1994 (Ford and Chambers 1974; EAEST 1995). However, evidence presented in the following section concerning laboratory and field studies of individual indicator species strongly contradicts that conclusion.

The most recent, long-term data sets for water temperatures and dissolved oxygen concentrations at Station F3 and elsewhere in the thermal plume are those obtained monthly by MEC Analytical Systems, Inc. (see, for example, MEC 1997, 2001). Therefore, it is logical that a representative set of these measurements be used. Data summaries for water temperatures and dissolved oxygen concentrations measured at Station F3 are shown in Table 1. These data summaries are for the six full calendar years 1997 – 2002. For dissolved oxygen, they combine values measured both near the surface and just above the bottom of the shallow water column at Station F3. For water temperatures, they combine values measured at 2-3 foot depth intervals in that water column from the surface to just above the bottom. It is important to note that dissolved oxygen concentrations reported by MEC were all measured during the day. Major diurnal changes occur in dissolved oxygen concentrations of inner San Diego Bay and other estuarine areas, resulting primarily from the changing balance between combined photosynthesis and respiration during daylight periods and respiration only during non-daylight periods (see, for example, Applied Science Associates 1998). Because of this, it is important to ensure that any limit applies to both day or night time periods.

In addition, it is obvious that ambient temperatures and those added by the thermal effluent change fairly markedly seasonally and from month to month (Tables 1 - 4). Because of this, it is logical and important to establish upper temperature limits for the compliance point that consider these month-to-month and seasonal changes.

These conclusions regarding water temperatures and dissolved oxygen concentrations were employed in setting limits for the compliance point. They form part of the final sections entitled Recommendations.

TEMPERATURE AND DISSOLVED OXYGEN LIMITS: EVIDENCE FROM LABORATORY AND FIELD STUDIES OF INDIVIDUAL SPECIES

Introduction

Effects of water temperatures and dissolved oxygen concentrations on marine invertebrates and fishes, as well as related temperature-salinity, temperature-toxicant, and oxygen-temperature interactions affecting these animals, have been studied extensively. See, for example, Kinne (1966, 1967, 1971), Newell (1970, 1973), Newell et al (1972), and Vernberg (1977). This has produced a substantial knowledge of the processes involved. However, only a few specific studies of this kind have been conducted for invertebrate and fish species inhabiting inner San Diego Bay.

Combined laboratory and field studies have been conducted concerning the temperature tolerances and preferences of four major species of larger marine animals that are important components of bottom communities in South San Diego Bay. They are the suspension feeding bivalve molluscs *Solen rosaceus* (rosy razor or pencil clam), *Tagelus californianus* (California jackknife clam), the filter feeding bivalve *Chione fluctifraga* (smooth cockle), and *Paralichthys californicus* (California halibut). These three bivalve species are dominant members of the benthic community. The smooth cockle also is important in recreational clamming and the pencil and jackknife clams are often used as bait by recreational fishermen. Juvenile and adult California halibut are important predators in South San Diego Bay and elsewhere. In addition, this demersal fish species supports major commercial and recreational fisheries in southern California. Areas such as inner San Diego Bay are thought to be nursery grounds for juvenile California halibut (Ford 1968, Michael Brandman Associates 1990). The studies concerning temperature relationships of these species are important to consider in setting temperature limits at the 1000-foot compliance point for the SBPP.

Rosy Razor Clam and California Jackknife Clam

Merino (1981) reported the results of a comprehensive field and laboratory study to evaluate the temperature tolerances of two important bivalve mollusc species common in South San Diego Bay. They are *Solen rosaceus* and *Tagelus californianus*. This study was conducted in conjunction with the early field studies for the South Bay Power Plant (Ford 1968; Ford et al 1970, 1971, 1972; Ford & Chambers 1973, 1975). The station designations he employed are those used in the initial studies by Ford (1968) and Ford et al (1970, 1971, 1972). Theses stations are shown in Figure 7.

Merino (1981) reported that the objectives of his study were to: 1) describe the physical environment in which both species exist; 2) describe their distribution and dispersion patterns in South San Diego Bay; 3) describe their important population characteristics; 4) evaluate the possible factors regulating these populations in both the natural and thermally altered environments of the inner Bay; and 5) describe and evaluate from laboratory and field studies effects of increased temperature on observed patterns of growth, reproduction and longevity in those natural and thermally altered environments. A major question was whether or not the elevated water temperatures in the vicinity of the cooling water channel of the SBPP were sufficient to change distribution and abundance patterns and the population characteristics of *S. rosaceus* and *T. californianus*.

The densities of *S. rosaceus* and *T. californiamus* in intertidal areas adjacent to the cooling water channel of the SBPP were influenced primarily by tidal elevation, water and sediment temperatures, recruitment and mortality (Merino 1981). High densities and large seasonal fluctuations in density were characteristic of *S. rosaceus* at the control stations. Low densities of *S. rosaceus* were characteristic of the thermal plume stations. Ford (1968), Ford et al (1970, 1971, 1972) and Ford & Chambers (1973, 1974) found few *S. rosaceus* in samples from within the cooling water channel, which apparently reflected their low resistance to elevated water temperatures in that channel area. Greatest densities of *S. rosaceus* were observed subtidally rather than at MLLW in the control station areas. At the stations outside the cooling water channel, densities were similar for both of these tidal elevations (Merino 1981). A possible explanation for this is that elevated water temperatures in the vicinity of the thermal plume stations that adversely affected *S. rosaceus* did so at both tidal elevations. That appears to be a logical explanation.

Merino (1981) found that *Tagelus californianus*, a much larger species, had much lower densities than *S. rosaceus*. This species also showed distinct seasonal fluctuations in abundance. Densities of *T. californianus* at both the outer thermal plume and control stations were similar but significantly greater than densities at the cooling channel and near field stations closest to the point of discharge from the SBPP. With respect to tidal elevation, densities of *T. californianus* at mid-intertidal locations were greater than those determined at low intertidal locations, except at the far field stations where densities were similar for both tidal levels. No *T. californianums* were found subtidally at the Station D2 (Figure 7) in the cooling channel, closest to the point of discharge. Water temperatures at this location apparently were too high for survival of the species.

Tagelus californianus was primarily a mid-intertidal species in the South Bay study areas (Merino 1981). It was not as abundant as *S. rosaceus* in either control or thermal plume station locations. This probably reflects differences in the body size and other biological characteristics of each species, rather than lack of resistance to high water temperature on the part of *T. californianus*. The greatest region of overlap between the two species occurred at the MLLW tide level.

The evidence from this study indicated that elevated water temperatures in the vicinity of the South Bay Power Plant were important in determining the large-scale distribution patterns and population characteristics of *S. rosaceus* and *T. californianus* (Merino 1981). The temperature buffering ability of the sediments offered some protection to *S. rosaceus* from upper lethal water temperatures. However, this species was restricted in distribution to areas where sediment temperatures rarely exceeded 82.4º F. On the other hand, the more temperature tolerant *T. californianus* were present, at least temporarily, where sediment and water temperatures approached 93.2º F.

Densities of *S. rosaceus* at the outer thermal plume stations were significantly less than those at the control stations (Merino (1981). These individuals grew faster; however, they attained a smaller maximum size, indicating that they were adversely affected. Similarly, densities of *T. californianus* within the cooling water channel were affected by the thermal effluent; their densities were less than those living at the control and outer thermal plume stations, indicating another adverse effect. The growth rate of *T. californianus* within the cooling water channel was greater than that of individuals living in areas beyond the end of the channel. They also attained a smaller maximum size in the channel, an indication of adverse effects. It is significant that the differences Merino (1981) observed within South San Diego Bay over a distance of only about three miles have been reported in the literature for this species only over latitudinal distances of hundreds of miles.

Merino (1981) found that reproduction of *S. rosaceus* and *T. californianus* may be "enhanced" within the thermal plume of the SBPP. This may be interpreted more properly as an adverse effect on these two species, rather than a beneficial "enhancement." The weight gains for individuals of both species suggested that spawning in the plume area extended into the late summer months. Indirect evidence for this extension of the spawning period also was indicated by the presence of juvenile *S. rosaceus* as small as 1.4 mm in shell length from samples taken during the winter months, and the presence of juvenile *T. californianus* in samples throughout much of the year.

Merino (1981) found that annual mortality rates of *S. rosaceus* were significantly higher at stations within the inner thermal plume (Stations D2 – D7) and concluded that this was due to higher water temperatures. The annual mortality rate of *T. californianus* was highest at Station D2 (Figure 7), a point very near to the initial discharge of thermal effluent from the SBPP. At this location *T. californianus* became an annual species. Recruitment into that group of individuals occurred in later summer and early fall, and the cohort died out completely during the next summer. Ford and Chambers (1973, 1974) reported such "annual species" effects for these and other bivalve molluscs present at the inner cooling water channel stations

An analysis of size-frequency distribution histograms suggested that *S. rosaceus* populations were characterized by one and possibly two recruitment waves per year in South San Diego Bay (Merino 1981). The apparent second wave was likely an extension of the spawning season in the thermal plume near the cooling water channel. A similar analysis for *T. californiamus* indicated that these populations were characterized by constant recruitment, exponentially decaying growth, and increasing mortality (Merino 1981).

The predominant random small-scale dispersion pattern of *S. rosaceus* and *T. californianus* in a fairly homogeneous environment, and the strongly size-class dominant populations, suggested insignificant adult-adult and significant adult-larval interactions, a possible regulating factor in their populations (Merino 1981). Regulation may occur by adults filtering spat and recently settled juveniles of their own species from the water column or resuspended sediments, causing reduced or failed recruitment.

Laboratory thermal tolerance and resistance studies indicated very clearly that *T. californianus* can withstand higher water temperatures than *S. rosaceus* (Merino 1981). The data obtained concerning resistance "effective time" predicts that *S. rosaceus* should not occur much closer to the point of thermal discharge than Station D7 (now designated F4) and D5 (Figures 6 & 7). This was verified by the results of the field studies. In contrast, the higher resistance to thermal effluent by *T. californianus* allowed this species to occur well within the cooling channel of the SBPP (Merino 1981).

Life history traits of both clam species differed between control and thermal plume station locations because of the influence of elevated water temperatures. Individuals from the inner thermal plume station locations were characterized by more variable reproductive effort, fewer young, (as determined by juvenile densities) and a shorter life span, while individuals from the control station locations were characterized by a more predictable breeding cycle resulting in numerous young. A longer life span and larger size also were characteristic of the sub-population unaffected by the increased temperatures in South San Diego Bay (Merino 1981).

Smooth Cockle

Kellogg (1975) conducted a similar combined laboratory and field study to consider the specific ecological and physiological effects of high water temperatures in the South San Diego Bay area on another dominant member of the benthic community, the smooth cockle, *Chione fluctifraga.* His approach allowed specific evaluations of growth rates, size-frequency relationships, temperature tolerances, mortality rates, and behavioral phenomena not possible or not easily discernable in a field study of infaunal species assemblages. Such specific lethal and sublethal effects of thermal effluent may be important at the species level and may lead to large-scale changes in distribution, abundance, species diversity and other ecological characteristics within the community (Kellogg 1975).

The specific effects of thermal effluent on *Chione fluctifraga* investigated by Kellogg (1975) included: 1) heat death under known thermal conditions; 2) altered growth rates in the field; 3) altered metabolism under measured thermal conditions in the laboratory; and 4) observations of behavioral phenomena related to thermal loading under laboratory conditions. The study was conducted, partly in conjunction with those of Ford and Chambers (1973, 1974), over the one-year period October 1971- September 1972 in order to obtain data on a long-term and seasonal basis. The station designations and positions employed by Kellogg (1975) were those of the original monitoring study (Ford 1968). They are shown in Figure 7.

Effects of Elevated Temperatures on Growth Rate

Kellogg reported that one important effect of elevated temperatures on the metabolism of *C. fluctifraga* was the acceleration of normal growth rates. Acceleration of growth rates was first observed in the cooling water channel at Station D5 (Figure 7), near the outer end of the channel during the period November 1971-April 1972. At that time growth rates at Station D5 (1.00 mm/month) were approximately five times greater than those at the control station (0.18mm/month) for the same period. The mean summer growth rate (0.77 mm/month) at the control station was similar to the mean winter growth rate at Station D5 (1.00 mm/month). Temperatures of 69.8ºF-78.8º F, characteristic of the cooling channel water during winter months, corresponded to water temperatures recorded during summer months at the control station. Kellogg concluded that the accelerated growth rates at Station D5 during winter months were the result of interjecting a warm water temperature regime in the thermal plume during a period when growth was normally reduced in the natural population. This clearly represents an adverse effect.

Growth rates at Station D7 (now designated F4 in Figure 6) were not significantly higher than those at the control station during any month of the study. Conversely, Kellogg (1975) observed that growth rates at Station D6 (Figure 7), nearby but just inside the cooling channel, were significantly higher than those at the control station during several months (April-July 1972). Because of the similarity in tidal elevation, sediment type, and water quality of Stations D6 and D7, water temperature differences between the two stations were the most apparent causal factor. Based in part on transplantation experiments in the field, Kellogg (1975) concluded this was strong evidence that accelerated growth rates of *C. fluctifraga* in this area of South San Diego Bay were due primarily to elevated water temperatures produced by the SBPP. He reported that at Stations D5 and D6 initial accelerated growth rates were not sustained beyond 4-6 months, regardless of the season in which he transplanted cockle clams into these cooling channel sites. Therefore, it is possible that for sustained, accelerated growth rates of *C. fluctifraga* to occur, an optimum temperature regime for tissue weight gain would have to prevail. This optimum temperature regime for tissue weight gain may be of a lower order than the optimum temperatures for shell growth.

Effects of Elevated Temperatures on Mortality

Kellogg (1975) found that mortality rates at the stations from D5 outward into the bay (Figure 7) varied appreciably from the mortality rates at the control station for both the whole local population and for individual age classes. However, mortality rates at Station D2 (Figure 7), located very near the point of discharge, were significantly higher during the summer months than mortality rates at the control station for the same period. Temperatures recorded at Station D2 during this period were in the range of 95.0ºF-102.2ºF; these corresponded to the range of lethal temperatures determined for *C. fluctifraga* in laboratory tests (Kellogg 1975).

In October 1973, one year after the end of regular monthly observations, an inspection of sampling stations revealed that a large number of mortalities of marked *C. fluctifraga* had occurred at all outer cooling channel stations (D5, D6, D7.) This observation suggested to Kellogg (1975) that although shorter (less than 1 year) mortality rates may not be affected by elevated temperatures throughout much of the cooling channel, long term (greater than 1 year) mortality rates can be affected substantially. Possible causes for high long-term mortality rates may include a basic metabolic disturbance, as indicated by evidence that was found of tissue weight loss (Kellogg1975). Further evidence of high long-term mortality rates included the repeated collections of small-sized live individuals (first-year age class), but rarely of larger-sized individuals (second and third live-year classes).

Thermal Resistance

Thermal resistance effective times determined by Kellogg (1975) for laboratory test temperatures of 98.6ºF and 102.2º F were 27 hours and 21 hours, respectively. This indicates that *C. fluctifraga* was protected from lethal effects due to short-term, high temperature thermal discharges throughout the cooling channel, because water temperatures in excess of 102.0 F were not sustained for periods of greater than 20 hours during any month of the study. However, slightly lower temperatures of approximately 95.0ºF were sustained at Station D2 during the summer season for periods that can produce a lethal effect (effective time of 164 hours). Therefore, heat death of *C. fluctifraga* due to long-term exposure (>160 hours) would be expected to occur at locations in close proximity to the point of discharge during these temperature conditions. High mortality rates at Station D2 were, in fact, observed in July and August of 1972 (Kellogg 1975).

An experimental procedure of subjecting *C. fluctifraga* to fluctuating temperatures was used to duplicate thermal conditions most often experienced by animals within the cooling water channel of the SBPP. Kellogg (1975) found that thermal resistance of animals subject to experimentally fluctuating temperatures did, in fact, vary significantly from estimates of thermal resistance made at similar but constant test temperatures. Effective time at a constant temperature of 98.6ºF was 27 hours. However, when subjected to fluctuating temperatures in the range of 85.1ºF-95.9ºF, the cockle clams showed no significant mortality (Kellogg 1975). Those subjected to conditions of alternating temperature were able to survive a total exposure to a normally lethal temperature (98.6ºF) for a period of 100 hours. The low number of mortalities at Stations D5, D6 and D7, where maximum temperatures of 98.6ºF occurred frequently but seldom persisted for more than 6 hours, provided direct field evidence for the survival of *C. fluctifraga* at what would normally be considered lethal temperatures. This shows that the results of such tests run at fixed temperatures may miss important features of the temperature tolerance process.

The survival of *C. fluctifraga* during periods of high and rapidly fluctuating temperatures within the cooling channel may be the result of its preadaption to naturally occurring extreme temperature conditions. For example, *C. fluctifraga* at the control station were regularly exposed to water temperatures of 86.0ºF and wide diurnal temperature fluctuations during tidal changes in the intertidal zone during the summer months. Based on this evidence, Kellogg (1975) concluded that innate heat resistance displayed by *C. fluctifraga* when subjected to fluctuating and elevated temperatures from the thermal discharge may reflect the preadaptions of an estuarine animal that has been historically exposed to relatively variable and severe natural temperature regimes.

The relationship between size and heat resistance of *C. fluctifraga* was not clearly evident (Kellogg 1976). There was limited evidence, although not statistically significant, of increased heat resistance with decreasing animal size. For example, at a test temperature of 102.2F the smallest size class (20-25 mm shell length) showed a slightly longer thermal resistance effective time than that of larger size classes. On the other hand, because this possible relationship between size and lethal temperature response could not be established in a more definitive manner, the significance of size-temperature responses was not addressed in his study.

Kellogg (1975) evaluated the ability of *C. fluctifraga* to carry on normal activities corresponding to the narrowest range of temperature within the zone of tolerance. This was done to distinguish subtle changes in normal activity patterns, indicating sublethal temperature stress, which could not be detected in studies of thermal resistance.

The most obvious deviation from observed normal activity patterns reported by Kellogg (1975) was decreased burrowing activity. This pattern was observed for a significant number (28/30) of animals after transfer to an aquarium held at a constant water temperature of 89.6ºF. Conversely, all animals (30/30) held in control aquaria at a temperature of 73.4ºF were found to be successfully burrowed in the substrate after approximately 15 minutes.

Decreased burrowing activity by cockles subjected to elevated temperatures in the cooling channel almost certainly would result in increased predation on *C. fluctifraga*. During periods of elevated temperature, significant numbers of cockles may be exposed on mudflats or in shallow water due to their decreased burrowing capacities. Given these conditions, increased predation by several known predators of *C. fluctifraga,* including shorebirds, rays and other fishes, could result. In fact, there was evidence for high levels of predation occurring on mudflats bordering the cooling channel (Kellogg 1975). Numerous shell fragments were observed on the sediment surface and also deposited in fecal material of unidentified shorebirds. Shell fragments were observed much less frequently on the nearby Sweetwater mudflats, suggesting a lower level of predation at those otherwise similar sites than that observed on mudflats bordering the cooling channel of the SBPP

Effects of Elevated Temperature on Oxygen Consumption

When temperature is increased abruptly, most poikilotherms show an initial overshoot in oxygen consumption, called a "shock reaction" (Kellogg 1975). In laboratory tests, the initially high oxygen consumption rates of *C. fluctifraga* stabilized in 1 to 2 hours. This probably was attributable to such a "shock reaction". Whatever the specific cause, the cumulative effect of frequent "shock reactions" to high temperatures would add to long-term metabolic stress of the individuals, producing adverse effects..

The Significance of Q_{10} Measurements

As indicated by Kellogg (1975), Q_{10} has often been applied in an effort to characterize metabolic rate responses of ectotherms to temperature. Normal Q_{10} values range from 2.0 to 3.0 for a variety of bivalve species. Values higher or lower than this have been interpreted as indicating metabolic sensitivity or insensitivity, respectively, to the temperature range involved.

The Q_{10}s determined for *C. fluctifraga* were relatively high for the temperature range of 73.4ºF-82.4ºF (Kellogg 1975). Q_{10}s of 4.4, 5.76, and 10.2 for the three respective age 1, 2 and 3 classes reflect a significant increase in the temperature-dependent Active Metabolic Rate (AMR) between these two temperatures. Q_{10s} less than one were reported for all age classes in the temperature range 82.4ºF-91.4ºF. Similar reductions in Q_{10} at high temperature levels have been reported for other bivalve species.

Kellogg (1975) suggested that the sharp decline of Q_{10} in the 82.4ºF-91.4ºF temperature range was caused by a shift in oxygen consumption rates from the AMR, which was displayed at lower temperatures, to a SMR. This was recorded for animals at 91.4ºF. The assumption of a temperature independent minimum rate of oxygen consumption (SMR), resulting in the decline of Q_{10} as lethal temperatures are approached, is well documented in the literature for a number of bivalve species.

In the normal environment, the standard rate of respiration of *C. fluctifraga* is presumably not affected appreciably by short-term fluctuations in temperature, such as those that would occur during tidal changes. However, the active rate of metabolism probably varies markedly with short-term temperature fluctuations, as demonstrated by Kellogg (1975) in laboratory testing of oxygen consumption rates. As a result, adjustments to brief diurnal periods of high temperature could result from a suppression of the Active Metabolic Rate.

In the discharge area of the South Bay Power Plant, periods of high temperature occur frequently and mean water temperatures are sustained at moderately high levels during much of the year. Metabolic adjustments are necessarily long-term in nature under these circumstances, rather than short-term as they are in response to the ebb and flow of tides (Kellogg 1975). Moderately high temperatures of 82.4ºF could result in a significant stimulation of the Active Metabolic Rate, as demonstrated in laboratory testing. Such a long-term stimulation of metabolic rate functions would eventually result in increased energy requirements for the cockles. However, if food supplies were not adequate to meet these higher metabolic needs, starvation or poor condition could occur (Kellogg 1975).

Kellogg concluded that temperatures of 91.4ºF or higher that occur in the cooling channel could result in additional problems involving long-term metabolic adjustments. Ordinarily the decline in the AMR and the assumption of SMR as short-term lethal temperatures are approached functions to conserve energy. However, the long-term result of restricting oxygen consumption to the SMR, and thus limiting activity levels at high temperatures, would be detrimental. Many vital life activities would be restricted, including feeding, predator avoidance and reproduction. As indicated by Kellogg (1975), the limitation of any one of these could result in the reduced abundance of cockles exposed to sustained high water temperatures.

California Halibut

Innis (1980, 1990) conducted laboratory simulation studies of juvenile California halibut, *Paralichthys californicus*, relevant to establishment of thermal limits. His objectives in this study were to evaluate behavioral responses of this species to a gradient of temperature and the effect of elevated temperatures in thermal effluent on growth. The results are of significant practical importance, as they describe the reactions of an important commercial and recreational species to thermal alterations of its natural habitat.

Temperature Preference Behavior

Innis (1980) reported that seven temperature preference experiments were conducted, using a total of 33 individuals, to study the response behavior of juvenile California halibut in a laboratory thermal gradient. These preference experiments were all carried out after a minimum of two weeks acclimation of the test animals at different temperatures.

The initial and final selected temperatures, as well as the shape of the frequency distribution of the temperatures selected, were used to describe the behavioral responses of *P. californicus* to temperature during each experiment (Innis 1980). The initial temperatures selected by California halibut in a thermal gradient after approximately the first 0.25-1.0 hour were generally similar in all tests. In all but one run, juvenile halibut were initially widely dispersed throughout the entire gradient chamber and did not display a uniform response relative to the newly formed thermal field. Instead, their response positions were related to their initial position in the chamber prior to the time when the gradient was formed.

Following the initial exposure to different temperatures, the juvenile halibut eventually began moving within the gradient, apparently testing the thermal field. In some cases, this response did not occur until after 2 hours of exposure, when extreme temperatures (78.8ºF –82.4ºF) apparently forced their movement. This "sitting" or "positioned" response (Ehrlich et al 1979) occurred commonly throughout all the experiments. The juveniles in these instances remained in one compartment, and withstood a wide range of temperatures for one hour or longer (Innis 1980). Occasionally, they moved into the extreme ends of the gradient as long as temperatures were within threshold temperature extremes, either warm or cool.

After the initial response to the gradient, in all but one case, the halibut continued to select a wide temperature range during the mid-portion (hours 2-5) of each experiment. During the last one-hour, groups of fish were still dispersed throughout the gradient. The separation of the fish groups was about the same as during the mid-experiment period, although these groups had shifted their positions.

The responses of juvenile halibut in the thermal gradient, despite wide ranging movements and separation of groups, was characterized by distinct modes in the frequency distributions of preferred temperatures selected (Innis 1980). In most instances, the modal selected temperatures were within the range of the initial and final selected temperature ranges.

Of the juvenile *P. californicus* tested, approximately half demonstrated a relationship between selected temperatures and their thermal history. The other half, for unknown reasons, appeared not to be influenced by the temperatures at which they were acclimated (Innis 1980).

Responses to temperature by *P. californicus* in an artificial thermal gradient, though varied, reflected natural behavioral responses. Temperatures of southern California bottom waters on the open coast, the habitat of larval, post-larval, and adult *P. californicus*, normally decrease with increasing depth, creating a gradient over a wide area. Differences in bottom temperatures with depth occur year round, but form to the greatest extent during winter. At that time, complete mixing of the water column causes bottom temperatures to increase. This occurs after a thermally stratified or upwelling season in which cool bottom water originating from the California Current reduce both nearshore bottom temperatures and depth-temperature differences substantially. In semi-enclosed marine areas, such as inner San Diego Bay and other estuaries and lagoons, the predominant environmental characteristics are the relatively wide and variable gradients in temperature and other factors. Tidal action is the most important ecological factor, with ebb and flow, as well as changes in water depth, quickly changing the structure of natural temperature gradients.

Thermal gradients also develop in association with the thermal effluent discharged from electrical generating stations. Thermal effluent plumes are variable in extent because of the changing intensity and direction of prevailing winds and tide flow. Start-up procedures and shutdown of units, as well as heat treatments to eliminate biofouling, can suddenly create, intensify or diminish thermally modified environments. The associated gradients of temperature radiating outward from point source discharges also will be affected by power plant operations.

Innis (1980) concluded that the behavioral responses exhibited by juvenile *P. californicus* reflect the varied environmental conditions occurring in estuaries. From the laboratory simulations, he observed different behavioral patterns, in which half of the juveniles selected warm temperatures, while the other half selected cool temperatures. This may represent a natural response rather than a laboratory artifact. Reactions of juvenile California halibut to thermal gradients are obviously eurythermal. This adaptive quality would be important for orientation and survival in an estuarine environment.

P. californicus changes habitats throughout its life cycle, with juveniles living in bays and estuaries and most adults moving to the open coast. Because of this, different temperatures become "optimal" at each major life history stage. Therefore, the eurythermal behavior of smaller, estuarine juvenile California halibut is naturally different from that of larger adults resident offshore. For larger individuals, a narrower temperature range would be optimal, because offshore areas are thermally less variable than nearshore or estuarine habitats (Innis 1980).

Both juvenile and adult *P. californicus* have relatively sedentary behavior. Methods of capturing prey and cryptic coloration with the sandy bottom reflect "ambush predator" habits, in which they lie in wait for prey. Coloration and the tendency to remain motionless to avoid predators also add to this general pattern of limited movement.

Innis (1980) concluded that this temperature response behavior of juvenile halibut observed in the gradient system probably was similar to the behavior they show in nature. The estuarine environment is highly dynamic and moderate changes in temperature occur in a diel cycle. Reactions by *P. californicus* in the artificial thermal gradient appeared to reflect similar response patterns (Innis 1980). Gradually increasing warmer temperatures, as generally found in a thermal plume, eventually evoked an avoidance response by *P. californicus* at 75º F-82.4ºF, while decreasing temperatures did not elicit avoidance movements by some individuals. In general, this species can tolerate a wide range of temperature, and juveniles seem to prefer relatively warm (59.0º F-73.5º F) temperatures.

This evidence suggested that juvenile *P. californicus* would not normally be affected by temperature conditions in thermal plumes from coastal generating stations (Innis 1980). Upon encountering the leading edge of a thermal plume, under most circumstances, juvenile California halibut would not avoid a 1º F ∆T. This would be the typical exposure from thermal effluent plumes on the open coast in southern California. In contrast, Innis (1980) concluded that thermal plumes in enclosed bays may elicit avoidance behavior because of the higher temperatures in such areas (i.e. South San Diego Bay: Ford 1968, Ford and Chambers 1974).

It is important for the reader to note that such avoidance behavior by juvenile *P. californicus* in South San Diego Bay may be a matter of ecological concern. Even though mobile animals such as the California halibut are able to avoid unsuitably high water temperatures in a thermal plume, this avoidance then prevents them from using the affected, high temperature area as a feeding or resting site. This may deprive individuals, particularly small juveniles, of their required food supply and some of their living space within parts of the thermal discharge pattern that they avoid all or part of the time. In addition, the absence of their predatory feeding activity may cause unnatural changes in their prey populations within thermally altered areas.

Thermal discharges from coastal generating stations with direct oceanic discharges also are known to act as attractive environments for *P. califo*rnicus (Stephens 1976, 1978). As reported by Innis (1980), it is likely that higher metabolic and growth rates are associated with their preference of warmer temperatures. One theory hypothesized by Webb (1978) was that predators at higher tropic levels, such as the top carnivore *P. californicus*, may take advantage of increased metabolic activity available when residing in or near discharge plumes. According to Webb's hypothesis, such discharge-orienting predators would have a "metabolic edge" over prey species because the predators usurp the localized areas of a thermal discharge. At higher metabolic rates, these fish could swim at faster bursts of speed in catching prey.

As a result, predators such as *P. californicus* within a warmer discharge area could obtain prey more easily. This mechanism would be advantageous to the California halibut, as their prey pursuit generally begins from a standing start as they burst out of the sediment. Many fish species in nearshore and bay environments of southern California appear to be attracted to the warmer temperatures near discharges, including those of inner San Diego Bay (Ford 1968). This would increase feeding opportunities of predators that orient to the thermal plume (Stephens 1977, 19780). However, from an ecological standpoint, all of these effects represent disturbances to both the fish populations and the natural marine communities involved.

Growth Studies

Innis (1980, 1990) investigated the possible long-term effects of thermal effluent on the growth rates of juvenile and sub-adult *P. californicus* (100-350 mm total length). Test animals captured at Agua Hedionda Lagoon by otter trawl during October and November 1976 were held in large, rectangular fiberglass troughs for approximately four weeks of laboratory acclimation. Test animals were fed daily in excess.

At the beginning of the four-week acclimation period, individuals of different size were distributed into two experimental tanks by randomization. After the individuals began to feed, one experimental group of 35 individuals was acclimated to 71.5ºF, a temperature corresponding to that typical of conditions in the thermal plume into the nearshore ocean from the adjacent Encina Power Plant. Temperature in this tank was increased at a slow rate from 59.0ºF-71.5ºF. The experimental temperatures were developed by mixing ambient temperature seawater from Agua Hedionda Lagoon with thermal effluent. The free-flowing mixture of the two water types was controlled by a pneumatic, Teflon coated mix-valve and epoxy coated pressure-proportioning thermostat (Ford et al. 1975). As a control, 34 individuals were held in flowing seawater at fluctuating ambient temperatures.

Using this system, the long-term effects of thermal effluent on growth were determined between 11 October and 27 August 1977, a 259-day period. Halibut held under ambient conditions in the laboratory experienced the coolest temperatures (57.2ºF-59.0ºF) during March and the warmest (72.5ºF-77.0ºF) during late July and early August. Thermal conditions in the mixed effluent-ambient treatment were warmer (71.6ºF±2.9ºF), and varied less than in the ambient temperature control water. Low rates of growth experienced by age class 2+ individuals held in both the control and thermal effluent treatment groups were due to the limited confines of the experimental system. Otherwise, growth of all age classes in the thermal effluent treatment was greater than in the ambient temperature control (Innis 1980, 1990). This result simply reflected the effect of moderately higher temperatures on the rate of growth. Because higher temperature conditions in a thermal effluent plume were not simulated in these experiments, the results are of limited use in predicting the effects on growth of California halibut in the warmer thermal discharge areas from the South Bay Power Plant.

Conclusions from the Studies of Individual Species as they Apply to Setting Temperature and Dissolved Oxygen Limits for the Compliance Point in the Discharge Channel of the South Bay Power Plant

The results of these combined laboratory and field studies of four important indicator species provide an additional dimension to the evaluation process. They help to explain the specific causes and processes involved in results obtained from the general ecological field monitoring studies of 1968-1994. For example, we know that *Solen rosaceus* was found only infrequently in samples within the discharge channel, and at different densities in other areas and within different tidal levels elsewhere. Specific knowledge of its thermal tolerances helps to understand what produced these observed distribution patterns.

In addition, these specific laboratory and field studies of individual species identified many more subtle, yet extremely important, adverse effects on growth, reproduction, burrowing activity, and other behavioral responses resulting from exposure to high temperatures in different parts of the inner and outer thermal plume. Such effects are seldom evident from typical field studies of the infaunal or fish species assemblages.

The results of these important species-specific studies must be considered in establishing temperature and dissolved oxygen limits at the compliance point that truly will protect beneficial uses of inner San Diego Bay. The studies indicate that water temperatures and dissolved oxygen concentrations measured monthly at Reference Station N2, located near, but outside the limits of the thermal plume (Figure 6), are the most suitable ones for establishing these limits. These data, obtained during the six full calendar years 1997-2002 as part of the NPDES monitoring, are summarized by month in Table 1. Using these data to set temperature and dissolved oxygen limits for the compliance point would provide the required protection of beneficial uses. These limits and their application are described in the following section entitled "Recommendations Employing Data from Station N2.

As an alternative, use of temperature and dissolved oxygen data from thermal plume Station F3 (Figure 6) to establish limits for the compliance point would provide only partial protection of beneficial uses. That would be a far less satisfactory solution. These limits and their application are described in the second section that follows, entitled Alternative Recommendations Employing Data from Station F3.

RECOMMENDATIONS EMPLOYING DATA FROM STATION N2

The following specific recommendations are made to establish maximum water temperature limits and minimum dissolved oxygen concentration limits for a compliance point in the discharge channel of the South Bay Power Plant. The results and information discussed in all previous sections of this report provide the specific data and justifications for these recommendations.

Recommendation 1

During each calendar month, maximum water temperatures of thermal effluent at the compliance point shall not exceed the individual monthly values shown in Table 2. These limits are based on the six-year (1997-2002) monthly data set obtained at Station N2 (Table 1).

Recommendation 2

During each calendar month, the concentrations of dissolved oxygen in thermal effluent at the compliance point shall not be lower than the specific monthly minimum limits shown in Table 2. This shall apply at all times of the day or night. Note that the lowest allowable concentration of dissolved oxygen recommended is 5.0 mg/L, as specified by the existing Basin Plan. That minimum value shall apply even during the warmest months of July-September. This is an ecologically sound overall minimum dissolved oxygen concentration for both freshwater and shallow, estuarine marine habitats. As indicated by Applied Science Associates (1998), "…a review of numeric water quality objectives for dissolved oxygen in other California regions and in other states with similar climatic conditions, revealed that 5 mg/L is a commonly used objective." Therefore, on both ecological and well-established regulatory grounds, setting the overall minimum concentration of dissolved oxygen at 5.0mg/L is logical and well justified for inner San Diego Bay.

Recommendation 3

In addition, as stated in the existing Basin Plan, the following specific water quality objective for dissolved oxygen shall apply: "The annual mean dissolved oxygen concentration shall not be less than 7 mg/L more than 10% of the time." (Basin Plan page 3-8).

Recommendation 4

At the compliance point, surface and bottom water temperatures shall be recorded continuously, to the nearest 0.1º F, using a data logger or similar device. At hourly intervals during the period 4am-5pm, dissolved oxygen concentrations shall be measured and recorded to the nearest 0.1 mg/L just below the water surface and near the bottom at the compliance point. A field polarographic oxygen electrode sampler or similar device accurate to at least 0.1 mg/L shall be employed.

Recommendation 5

These daily records of temperature and dissolved oxygen shall be reported to the San Diego Regional Water Quality Control Board, and used by both the Board and the discharger to assure compliance with the established maximum water temperature and minimum dissolved oxygen concentration limits.

Recommendation 6

As a means of assessing the effectiveness of the established temperature and dissolved oxygen limits, a seasonal, quantitative marine ecological monitoring program shall be conducted at the compliance point and at a series of other representative stations within and outside the extent of the thermal plume, including Station F3 and Station N2 (Figure 6). This shall consist of taking and analyzing a minimum of five replicate, 0.l sq.m Van Veen grab samples at the compliance point and at the other station sites. These biological samples shall be taken and analyzed seasonally on at least a quarterly basis. Quantitative data for the invertebrate infauna from these sediment samples shall be evaluated on a comparative basis, using the approaches employed by Ford and Chambers (1973, 1974) and as summarized by E.A. Engineering, Science, and Technology (1995). A primary emphasis of this ecological monitoring shall be to determine whether or not temperature and dissolved oxygen conditions at the compliance point in the discharge channel have had any significant adverse effects on the infauna. If so, then the temperature and dissolved oxygen limits for the compliance point shall be modified to eliminate those adverse effects.

ALTERNATIVE RECOMMENDATIONS EMPLOYING DATA FROM STATION F3

Recommendation 1

During each calendar month, the maximum water temperature limits of thermal effluent at the compliance point shall not exceed the individual monthly limit values shown in Table 4. These limits are based on a six-year (1997-2002) monthly data set for Station F3 (Table 3).

Recommendation 2

During each calendar month, the concentration of dissolved oxygen in thermal effluent at a compliance point shall not be lower than the minimum limit shown in Table 4. These minimum limits shall apply at any time of day or night. Note also that the lowest allowable concentration of dissolved oxygen recommended is 5.0 mg/L, as specified in the existing Basin Plan. That minimum value shall apply even during the warmest months of July-September. This is an ecologically sound overall minimum dissolved oxygen concentration for both freshwater and shallow, estuarine marine habitats. As indicated by Applied Science Associates (1998), "…a review of numeric water quality objectives for dissolved oxygen in other California regions and in other states with similar climatic conditions, revealed that 5 mg/L is a commonly used objective." Therefore, on both ecological and well-established regulatory grounds, setting the overall minimum daytime concentration of dissolved oxygen at 5.0mg/L is logical and well justified for the compliance point of the South Bay Power Plant.

Recommendation 3

In addition, as stated in the existing Basin Plan, the following specific water quality objective for dissolved oxygen shall be met: "The annual mean dissolved oxygen concentration shall not be less than 7 mg/L more than 10% of the time." (Basin Plan page 3-8).

Recommendation 4

At the compliance point, surface and bottom water temperatures shall be recorded continuously, to the nearest 0.1ºF, using a data logger or similar device. At hourly intervals during the period 4am-5pm, dissolved oxygen concentrations shall be measured and recorded to the nearest 0.1 mg/L just below the water surface and near the bottom at the 1000 foot compliance point. A field polarographic oxygen electrode sampler or similar device accurate to at least 0.1 mg/L shall be employed

Recommemndation 5

These daily records shall be reported to the San Diego Regional Water Quality Control Board, and used by both the Board and the discharger to assure compliance with the established maximum water temperature and minimum dissolved oxygen concentration limits.

Recommendation 6

As a means of assessing the effectiveness of the established temperature and dissolved oxygen limits, a seasonal, quantitative marine ecological monitoring program shall be conducted at the compliance point and at a series of other representative stations within and outside the extent of the thermal plume, including Station F3 and Station N2. This shall consist of taking and analyzing a minimum of five replicate, 0.l sq.m Van Veen grab samples at the compliance point and at the other thermal plume and reference station sites. These biological samples shall be taken and analyzed seasonally on at least a quarterly basis. Quantitative data for the invertebrate infauna from these sediment samples shall be evaluated on a comparative basis, using the approaches employed by Ford and Chambers (1973, 1974) and as summarized by E.A. Engineering, Science, and Technology (1995). A primary emphasis of this ecological monitoring shall be to determine whether or not temperature and dissolved oxygen conditions at the compliance point in the discharge channel of the SBPP have had any significant adverse effects on the infauna. If so, then the temperature and dissolved oxygen limits for the compliance point shall be modified to eliminate those adverse effects.

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TABLE 1

Summary of water temperatures and dissolved oxygen concentrations measured monthly at Station N2 in South San Diego Bay (Figure 6) during the six full calendar years 1997-2002. Data are those reported to the San Diego RWQCB by MEC Analytical Systems, Inc., Carlsbad, CA. Water temperature measurements were made at 2-foot depth intervals in the water column from near the surface to just above the bottom on each date. Dissolved oxygen concentration data (DO) include daytime measurements made near the surface and just above the bottom on each date. All data were pooled for each month.

	Water Temperature (ºF)		Dissolved Oxygen (mg/L)	
Month	**Max. Temp.**	**Temp. Range**	**Min. DO**	**DO Range**
January	62.4	57.0-62.4	8.0	8.0-10.3
February	62.2	55.0-62.2	7.6	7.6-8.17
March	66.6	59.4-66.6	7.5	7.5-8.4
April	68.4	60.7-68.4	6.4	6.4-8.9
May	72.4	69.8-72.4	6.5	6.5-7.7
June	76.1	72.5-76.1	6.7	6.7-8.0
July	78.1	72.5-78.1	6.5	6.5-8.0
August	79.9	76.1-79.9	6.2	6.2-8.5
September	78.1	73.0-78.1	4.7	4.7-8.6
October	73.2	70.2-73.2	5.9	5.9-8.2
November	67.9	60.4-67.9	7.1	7.1-9.1
December	66.7	56.3-66.7	7.0	7.0-8.4

TABLE 2

Recommended maximum water temperatures and minimum dissolved oxygen concentrations for the compliance point in the cooling water channel of the South Bay Power Plant. These limits are shown separately for each calendar month. The values shown are based on the six-year monthly data summaries for Station N2 provided in Table 1. Temperatures were rounded up or down to the nearest whole number. The lowest overall dissolved oxygen concentration recommended is 5.0 mg/L.

Month of	Max. Temp. (ºF)	Minimum Daytime Dissolved Oxygen Conc. (mg/L)
January	62	8.0
February	62	7.6
March	67	7.5
April	68	6.4
May	72	6.5
June	76	6.7
July	78	6.5
August	80	6.2
September	78	5.0
October	73	5.9
November	68	7.1
December	67	7.0

TABLE 3

Summary of water temperatures and dissolved oxygen concentrations measured monthly at Station F3 in South San Diego Bay (Figure 6) during the six full calendar years 1997-2002. Data are those reported to the San Diego RWQCB by MEC Analytical Systems, Inc., Carlsbad, CA. Water temperature measurements were made at 2-foot depth intervals in the water column from near the surface to just above the bottom on each date. Dissolved oxygen concentration data (DO) include daytime measurements made near the surface and just above the bottom on each date. All data were pooled for each month.

	Water Temperature (ºF)		Dissolved Oxygen (mg/L)	
Month	**Max. Temp.**	**Temp. Range**	**Min. DO**	**DO Range**
January	68.7	59.1-68.7	5.9	5.9-9.2
February	66.9	58.8-66.9	6.7	6.7-8.0
March	67.5	61.3-67.5	6.5	6.5-7.8
April	76.3	63.8-76.3	5.4	5.4-7.8
May	81.4	70.3-81.4	5.0	5.0-6.6
June	84.2	74.4-84.2	5.0	5.0-6.5
July	85.5	77.7-85.5	4.8	4.8-6.6
August	85.4	78.6-85.4	5.2	5.2-7.8
September	83.8	75.8-83.8	4.2	4.2-7.8
October	77.5	72.8-77.5	5.0	5.0-6.6
November	73.8	63.7-73.8	6.3	6.3-9.7
December	66.0	58.9-66.0	6.3	6.3-9.6

TABLE 4

Recommended maximum water temperatures and minimum dissolved oxygen concentrations for the compliance point in the cooling water channel of the South Bay Power Plant. These limits are shown separately for each calendar month. The values shown are based on the six-year monthly data summaries for Station F3 provided in Table 3. Temperatures were rounded up or down to the nearest whole number. The lowest overall dissolved oxygen concentration recommended is 5.0 mg/L.

Month of	Max. Temp. (ºF)	Minimum Daytime Dissolved Oxygen Conc. (mg/L)
January	69	5.9
February	67	6.7
March	67	6.5
April	76	5.4
May	81	5.0
June	84	5.0
July	85	5.0
August	85	5.2
September	84	5.0
October	78	5.0
November	74	6.3
December	66	6.3

Deadly Power

A case for eliminating the impacts of the South Bay Power Plant on San Diego Bay and ensuring better environmental options for the San Diego/Tijuana region.

Prepared by the

San Diego Bay Council

A coalition of San Diego environmental organizations dedicated to protection and restoration of San Diego's coastal water resources

Member Organizations

Environmental Health Coalition
San Diego Audubon Society
San Diego BayKeeper
San Diego Chapter of the Sierra Club
San Diego Chapter of the Surfrider Foundation
Southwest Wetlands Interpretive Association
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December 3, 2001

Deadly Power:

A case for eliminating the impacts of the South Bay Power Plant on San Diego Bay and ensuring better environmental options for the San Diego/Tijuana region.

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Deadly Power

Executive Summary

The South Bay Power Plant has been responsible for severely degrading the San Diego Bay ecosystem with thermal and chemical pollution and by killing a wide range of juvenile, larval, and adult organisms in its cooling system for more than 40 years. These impacts are severe and continual. This degraded condition is now so long-standing that it is considered the "base-line" for South Bay. This grossly inefficient plant is also a source of air pollution and a visual blight on the community.

Soon, plans will be developed for a replacement for the South Bay Power Plant. We cannot let the degradation and destruction of San Diego Bay continue through the use of bay water for cooling. Now is the time to stop the *"cooling that kills."* The evidence in this report makes it clear that:

- the negative environmental impacts from the South Bay Power Plant to San Diego Bay are significant;
- there are feasible, viable, and protective alternatives for replacement of the South Bay Power Plant;
- the current permitting structure is inadequate; and
- government must act now to eliminate the damage to San Diego Bay.

The member organizations of the San Diego Bay Council, representing 22,000 San Diegans, are committed to act through community involvement, regulatory participation, and legal action, to ensure that the South Bay Power Plant is torn down and its damaging impacts to sensitive South San Diego Bay are ended. The Bay Council urges agencies with authority over the South Bay Power Plant to aggressively pursue the following actions:

I. Build a State of the Art, Dry-Cooled Power Plant to Replace the South Bay Power Plant

The South Bay Power Plant must be torn down and replaced as soon as possible with a more efficient, dry-cooled plant and there must be aggressive commitments to conservation and clean, renewable energy sources. This will result in less air and water pollution and use of less hazardous materials in the region. Officials should establish an enforceable time line to phase out the South Bay Power Plant.

2. Provide Comprehensive and Meaningful Regulation of the Existing Power Plant

The South Bay Power Plant's National Pollution Discharge Elimination System (NPDES) permit is up for a five year renewal. In the near-term, the Regional Water Quality Control Board must require new, more protective requirements for the discharges into San Diego Bay. The Regional Board should include a permit condition or resolution that clearly states that any replacement plant should not use Bay water for cooling and that impacts from current practices should be fully mitigated and the Bay should be restored. The monitoring regime for the new permit should include discharge and receiving water limits and monitoring for all constituents known to be present in the discharge. It should also be designed to fully assess impacts on beneficial uses.

3. Recognize the Impacts of the South Bay Power Plant on South San Diego Bay

Impacts to marine life of South Bay will not be addressed until we recognize the extent of the problem. South Bay is heavily impacted by the power plant discharges and cooling process itself. South San Diego Bay should be added to the 303(d) list of "impaired" waterbodies so that it receives priority action for protection.

Biological and Ecological Impacts

The South Bay Power Plant is a steam electric power generating facility located at the far southeast shore of San Diego Bay, surrounded by sensitive mudflat habitat. The plant uses what is called a once-through wet-cooling system that draws cooling water from San Diego Bay. This heated cooling water is then discharged back into the Bay. At full capacity, 601 million gallons of water are discharged back into the Bay each day. Other California power plants use this cooling method, but draw from and release water to the open ocean, where the volume of the water body greatly exceeds the amount being used and where the heated water is more quickly dissipated.

South San Diego Bay is a sensitive marine environment, highly vulnerable to thermal, chemical and other pollution sources. The south bay environment is most vulnerable in summer, the time of year that the SBPP releases the most thermal pollution because of increased summer energy demands. Water discharged from the plant can reach temperatures over 100°F, a lethal temperature for fishes and other marine life. The plant also releases toxic chemicals in discharged water, including copper, nickel, zinc, chromium and chlorine. The high temperatures exacerbate the effects of chemical pollution on marine life.

There is no maximum temperature limit for SBPP discharges. Between 1974 and 2000, average discharge temperatures have risen over 10°F in both summer and winter. Permitted increases in temperature between intake water and water discharged from the SBPP have risen from 12.5°F to 15°F. The higher water temperature decreases the amount of dissolved oxygen in the water and, at the same time, increases the metabolic rate of animals which increases their oxygen demand. The plant discharges dead plants, fishes, shellfish and other organisms back into the Bay and the decay of these plants and animals further reduces oxygen levels.

The South Bay Power Plant has been disrupting the ecosystem of South San Diego Bay for more than 40 years. Roughly 20 percent of the water in the South Bay is drawn into the plant every day. Early life stages of marine plants and animals also are drawn into the cooling water system, where they are subjected to mechanical damage, as well as chemical, temperature and pressure shock. The loss of early life stages of fish, shellfish and other invertebrates, and other microscopic plants and animals that form the base of the food chain may affect the overall ecological balance of the Bay. Millions of these organisms are lost in the Power Plant each year.

Adult fish and invertebrates in the vicinity of the SBPP intake are drawn into the intake structure and impinged, or trapped, by either a "trash rack" or a series of screens. A 1979-1980 study considered impingement and estimated that 28,174 individual fish were killed in the plant in 1979.

A major concern is the use of up to 4,100 pounds of chlorine per month for the purposes of killing marine life in the intake water. The highly chlorinated water is then discharged back into the Bay. Almost all species of animals are hit hard by chlorine, and this effect is exacerbated in a shallow, poorly circulated environment like the South Bay. In addition to its immediate effects, chlorine is now known to break down, complex with other substances, and form new compounds such as chlorinated organics. These chlorinated organic compounds can remain toxic for aquatic life for long periods. The SBPP uses more chlorine in summer, compounding the effects of higher summer water temperature, less dissolved oxygen, and the greater toxicity of other chemicals.

The SBPP also releases an estimated 400-1020 pounds of copper, a heavy metal that is highly toxic to marine life and which is known to accumulate in fish and shellfish, into the Bay each year. Nickel concentrations in the cooling water have also been significant. Zinc waste plates, used for corrosion control, release zinc into the cooling water. For fishes, a decrease in oxygen levels of the water increases the apparent toxicity of zinc and copper. Water temperature is possibly the most important factor affecting zinc toxicity: the higher the temperature, the shorter the survival time. The juvenile inhabitants of South Bay are more sensitive to these metals than adult animals.

Eelgrass (Zostera marina) forms a distinct marine habitat providing vital shelter and food for many bay inhabitants. For some reason, eelgrass is absent in the vicinity of the plant, yet plentiful west of the plant and in other areas of the South Bay. Eelgrass is highly dependent on sufficient light to thrive, and declines in seagrass abundance have been linked to decreasing water transparency. Without the power plant discharge, we would expect a resurgence of eelgrass beds.

One problem associated with securing reliable information about the impacts of the plant is that the data we have is not independent of the discharger. Many of the existing studies are suspect because they were funded by the discharger with a significant interest in the conclusions of the studies. Independent assessment of the impacts of the power plant is needed.

Efficiency and Economics

The South Bay Power Plant energy conversion efficiency is about 38 percent compared to modern day power plants which have design efficiencies upward of 56 percent. A new plant that generates the same amount of electricity would use significantly less natural gas and emit less air pollution. Efficient use of natural gas is critical given the negative air quality impacts of burning oil and the limited supply of natural gas. Further, two-thirds of the cost of operating a fossil fuel plant is the cost of fuel.

There are feasible, viable, and protective alternatives to once-through wet-cooling. Dry-cooling has been available for more than 40 years and has been used in all climates with several in arid regions of Mexico and the United States. Dry-cooling uses air instead of water to cool the low-pressure steam leaving the steam turbines. Large radiator-type tube banks are used to transfer heat from the condensing steam to air passing over the tubes. Dry-cooling has no air or water polluting emissions. There is no water evaporation, no visible plume, no thermal discharges, and no particulate air emissions associated with the cooling. Water is only needed for periodic system maintenance and cleaning. Dry cooling could result in reductions in water use by more than 99 percent over once-through wet-cooling. Through such reductions in water use, the need to use water from any sensitive or biologically productive water body is removed. Further, dry cooling does not need to sterilize the water it uses for cooling so the use of chlorine is eliminated.

There are over 600 electric power plants throughout the world that use dry-cooling, including 50 in the United States. These plants are of a variety of sizes, types, and located in a variety of climates including one planned in Otay Mesa.

Recommendations

, The **State Water Resources Control Board** should

< ensure that the updated Thermal Plan provides more protective requirements regarding thermal discharges into state waters. The update should strengthen protections for estuaries and enclosed bays. The new Thermal Plan should prohibit the use of natural surface waters for cooling of power plants since feasible alternatives exist.

< add the waters of South San Diego Bay to the 303 (d) list as impaired for heat, chlorine, and copper.

, The **Regional Water Quality Control Board** should

< specifically address requirements on any replacement plant for the SBPP and make clear the intent of the Board for any future proposal. This could be accomplished through a condition in the new NPDES permit or a resolution requiring any reconstruction/repower during this permit duration to carry a "new discharge" designation and, thus, subject to much more stringent requirements.

< strengthen the NPDES permit, increase monitoring, and require mitigation for damage caused by the operation of the SBPP in order to ensure protection of beneficial uses in San Diego Bay. The new permit should move closer to the elimination of water quality impacts from the power plant discharges as soon as possible. Essential changes include: establish limits and monitoring requirements for dissolved oxygen and all constituents present in the discharge such as metals and chlorine by-products; relocation of the compliance point to the real point of discharge (i.e. end of the pipe); set maximum temperature limits for the discharge; establish impingement and entrainment limits; establish sediment monitoring; and increase frequency of chlorine monitoring.

< ensure that storm water requirements are incorporated into the renewed NPDES permit and strengthened to include, at a minimum, acute toxicity and diversion of storm water from high risk areas.

, The **San Diego Unified Port District** should renegotiate the lease for the power plant and the Port should ensure that any operator is held to hard and fast deadlines for removal of the SBPP. A requirement should be added that any new plant on Port District tidelands must utilize dry cooling.

, The **California Energy Commission** should require all new and repowered plants to use dry cooling.

, The **San Diego Regional Energy Office** should recommend an aggressive Regional Energy Strategy that pursues conservation, efficiency, and clean renewable energy to the maximum extent possible for the San Diego/Tijuana region.

Deadly Power:

A case for eliminating the impacts of the South Bay Power Plant on San Diego Bay and ensuring better environmental options for the San Diego/Tijuana region.

Introduction

San Diego Bay is the crown jewel of San Diego. It is a magnificent natural and recreational resource and supports considerable economic activity in the region. It provides us with a beautiful backdrop for our city and is home to hundreds of resident and migrating wildlife species. It is invaluable for its commercial, industrial, and military uses and as a natural ecosystem. Balancing these uses has always been difficult and the health of the Bay ecosystem has, over time, suffered as a result.

San Diego Bay has, for too long, been negatively impacted by the uses around it. It is the recipient of polluted discharges from industrial and military operations as well as polluted runoff from the urbanized watershed. The result is that Bay fish and sediments have become contaminated and constant pollutant loading has taken a toll on the health of the Bay. One of the most devastating current impacts on the ecological health of San Diego Bay is the use of bay water for cooling by the South Bay Power Plant. In the past few years, there have been significant actions initiated to restore the Bay to health. This report focuses on the next action that must be initiated–**we must set a course to stop the use of bay water to cool the South Bay Power Plant.**

Power generation in San Diego/Mexico has commanded our attention in recent months due to apparent energy shortages that have now become surpluses. Out of all the confusion about where we get our power and how it is generated, one thing about our energy future is clear–we need to set a long-term goal to develop a binational strategy that promotes energy conservation and use of renewables and energy development that protects binational air basins and water resources from further degradation or depletion. This is a large task. How protective and environmentally sustainable this future will be relies, in strong measure, on how the repower or replacement of the South Bay Power Plant is achieved.

This report does not seek to answer all questions or issues related to the power generation future of the region. This report does seek to do the following:

- provide clear evidence that the negative environmental impacts to San Diego Bay are significant.
- ensure that these significant impacts are properly reflected in how we regulate these discharges.

- make recommendations to ensure that damaging impacts from the SBPP are reduced and eliminated as soon as possible.
- ensure that permits, policies, and governmental actions are initiated to ensure the ultimate replacement of the South Bay Power Plant for the good of economic development in the South County and that will greatly reduce the environmental impacts to the region.

Section I

Permitting History and Regulation of the South Bay Power Plant

A. South Bay Power Plant (SBPP) Timeline

1960 SBPP begins operation

The first of four generating units of the SBPP began operations in 1960 prior to the promulgation of the Federal Pollution Control Act of 1972 and its amendments that formed the Clean Water Act in 1977. The other three units followed in 1962, 1964, and 1971.

1969 First Permit: Resolution 69-R3

The first Regional Water Quality Control Board permit allowed condenser cooling water (three units) discharges of 425 million gallons a day (MGD), boiler blowdown wastes, and 100 pounds a day of copper sulfate for corrosion control. Dissolved oxygen (DO) was monitored **weekly.** This permit specified the average and maximum differential temperatures between the discharge and the inlet cooling water (discharge minus inlet). The average differential was 12.5ºF and the instantaneous maximum was 18.5ºF. However, the permit lacked a maximum discharge temperature specification which leaves the waste heat discharges open-ended.

1974 Permit renewal: Order 74-91

Renewal permitted a discharge of 434 MGD cooling water and noted an average summer water discharge temperature of 78º and winter discharge temperature of 61ºF.[1]

1975 The California Thermal Plan last revised.

The Thermal Plan (originally adopted in 1971) "grand-fathered" several power plant discharges as long as they met certain standards. Standards for existing discharges to designated estuaries were much higher than for enclosed bays. San Diego was determined to be an *"enclosed bay"* for purposes of the Thermal Plan.[2] The cost of upgrading old plants and the expectation that

[1]Order 74-91, Finding 3.

[2]*Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California*, State Water Resources Control Board, adopted 1975.

old plants would be replaced with newer, cleaner technology factored into the State Board's decision to allow existing discharges, like the SBPP, to continue.[3] It is meaningful that the Thermal Plan prohibited **new** thermal waste discharges having a temperature greater than 4°F above natural temperature of the receiving water.[4]

1976 Permit Renewal and addenda: Order 76-10

The NDPES permit renewal and addenda raised flows to 600.5 MGD and listed the temperatures in the water as much higher, with an average temperature in summer of 91°F and an average winter temperature of 74° F.[5] Chlorine was monitored **monthly.** The permissable temperature difference between the discharge and intake water was increased to 15°F average with a 25°F instantaneous maximum. Dissolved oxygen was (DO) not monitored.

1985 Permit Renewal: Order 85-09

This Order permitted industrial waste discharges to the Bay. It maintained a compliance monitoring point far from the actual discharge from the plant. Chlorine was monitored **monthly.** DO was not monitored.

1996 Permit Renewal: Order 96-05

This permit was adopted after a bitter fight between SDG&E and the environmental community. It was appealed by both SDG&E and Environmental Health Coalition and resolved, in part, through settlement discussions. It succeeded in achieving a phase-out of some of the industrial process water discharges like the metal cleaning wastes and relocated the "discharge compliance point" at the edge of the power plant property line, about 100 feet from the actual discharges. This change was made for all constituents **except for the temperature limit[6] which is located 300 yards downstream** from the actual discharge point. The official "point of discharge" is located one mile from the actual point of discharge at the end of the rock jetty in the middle of the South Bay. There are no receiving water limitations for DO in the current permit and the discharge water is not monitored at all for DO.

1999 SBPP Sold to Port of San Diego, Leased to Duke

SBPP purchased by the San Diego Unified Port District for $110 million and leased to Duke Energy Power Services for 10 years. The agreement reached between Duke and the Port

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[3]Legal Memorandum, from Craig Wilson, State Water Resources Control Board, March 24, 1999
[4]Thermal Plan, p. 5.
[5]Order 76-10
[6]Order 96-05, p. 17.

required that "*commercially reasonable efforts*" be made to develop a replacement plant and to decommission and remediate the existing facility.[7]

1999

South San Diego Bay National Wildlife Refuge established by the Port District, State Lands Commission and the US Fish and Wildlife Service. Management planning begins to restore some of salt ponds and degraded areas to estuarine habitats.[8]

2000

Duke Power reported that the average winter temperature for the discharge water was 73.8ºF and the average for the summer discharge water was 89.3ºF.[9] The maximum discharge temperatures were 76.3ºF in the winter and 94.3ºF in the summer.

2000

Duke begins discussions about a replacement of SBPP[10] with a water-cooled plant.[11] All options under consideration rely on varying levels of bay water for cooling and contemplate reliance on the existing 15ºF limit between the intake and the discharge water.

2001

Governor Gray Davis issues Executive Order D-22-01. The EO ordered the State Water Resources Control Board to ensure that power plants *"... are not precluded from operating as a result of thermal limits in waste discharge requirements."*

June 2001 Duke requests increases in heat discharges

In midst of an energy crisis, Duke Power requests that the Regional Board allow even further elevation of the waste heat discharge to the Bay by raising the average daily differential

[7] Staff report to the State Lands Commission, January 29, 1999, p. 2.

[8] http://sandiegorefuges.fws.gov/new/ccp/CCP%201%20Index.htm

[9] Summary of Year 2000 Discharge Monitoring Report Data, Application for Renewal of the NPDES Permit for Duke Energy South Bay LLC's South Bay Power Plant, EPA Form 2C, Appendix A, May 4, 2001

[10] The SBPP is designated by the state as a "must-run" plant, meaning that a new plant must be built before this existing plant is decommissioned.

[11] Letter from Margaret Rosegay, Pillsbury, Madison and Sutro, LLP to Craig M. Wilson, State Water Resources Control Board, November 3, 2000.

temperature from 15ºF to 23ºF.[12] Concerns of resource agencies caused Duke to withdraw request.[13] Concern of environmental community is significantly raised that the plant could continue to do even more damage to the Bay.

The Engineering Evaluation for the South Bay Plant submitted into the record by Duke showed that the plant could generate 725 MW gross output with the inlet water at 81ºF and the outlet water between 97ºF and 106ºF. Proposed scenarios for increases in operations showed predicted outlet temperatures as high as 107.5ºF from some units.[14]

Spring-Summer 2001 Duke and Other Energy Suppliers Come under Fire

Duke Power and other energy suppliers charged with profiteering by utilizing deregulation to manipulate California's energy supply. Stories of manipulation of the energy crises appear prominently in the Los Angeles Times, San Diego Union Tribune, national newspapers and electronic media. Intense public scrutiny follows.

2001 Permit renewal

Permit is up for its five year renewal in December. Hearing is expected to be held on December 12, 2001. The Tentative Draft NPDES Order 2001-283 proposes very few changes to existing monitoring and regulatory requirements outlined in the 1996 permit.

B. Regulation of Power Plant Water Discharges–Legal Framework

Clean Water Act

Under the Clean Water Act (CWA), states are required to issue National Pollutant Discharge Elimination System (NPDES) permits for thermal discharges, as well as other discharges that impact water quality and beneficial uses, subject to United States Environmental Protection Agency's (EPA) approval. These permits are issued by the State Water Resources Control Board (State Board) and Regional Water Quality Control Boards (Regional Boards), in accordance with the CWA, EPA, and any more stringent state requirements. The Porter-Cologne Water Quality Act (Porter-Cologne Act) allows California to both implement the CWA and assume responsibility for its NPDES permit program. Under the Porter-Cologne Act, State

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[12]May 7, 2001 letter from Mr. Mark Hays, Duke/Fluor Daniel to Mr. John Robertus, Regional Water Quality Control Board, p. 5.

[13]*Duke Energy drops warm-water request*, San Diego Union Tribune, June 14, 2001; Letter from Mark Hayes, Duke Energy to John Robertus, Regional Water Quality Control Board June 13, 2001.

[14]Engineering Evaluation for South Bay, Attachment 3 to May 7, 2001 letter from Mr. Mark Hays, Duke/Fluor Daniel to Mr. John Robertus, Regional Water Quality Control Board.

and Regional Boards have additional authority to review and modify waste discharge requirements for point sources. However, the modifications must be consistent with the NPDES program requirements.

California Toxics Rule

The California Toxics Rule is a comprehensive list of criteria for priority toxic pollutants that was created to satisfy section 303(c)(2)(B) of the CWA.[15] It governs pollutant discharges into inland waters, bays, and estuaries of California. It was created to assist those issuing permits to apply appropriate waste discharge requirements for individual pollution sources discharging priority toxic pollutants.

303(d) Listing

Section 303(d) of the Clean Water Act requires States to identify "impaired" water bodies based on their inability to meet water quality objectives. This list is updated every two years, though the last scheduled update (2000) was postponed as new regulations were being promulgated. The most recent (1998) 303(d) listing included 36 separate impaired water areas in San Diego, including portions of San Diego Bay. The draft 2002 list proposes to increase that number to 60 separate water areas.[16]

The ad hoc workgroup of Regional Boards, State Board and EPA staff has developed guidelines for use by the Regional Boards in recommending additions or changes to the 303(d) list. Some of the factors considered include:

- Effluent limitations or other pollution control requirements are not stringent enough to *assure protection of beneficial uses* and *attainment of SWRCB and RWQCB objectives.*
- *Beneficial uses are impaired* or are expected to be impaired within the listing cycle (i.e., in next two years). Impairment is based upon evaluation of chemical, physical, or biological integrity. Qualitative and quantitative assessment of physical/chemical monitoring data, bioassay tests, and/or other biological monitoring will determine impairment. Federal and State criteria and statewide and Regional Water Quality Control Plans determine the basis for impairment.

Beneficial uses are defined in the San Diego Basin Plan as *"the uses of water necessary for the survival or well being of man, plants and wildlife."* [17]

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[15]SWRCB, California EPA, Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California, 2000.

[16]Draft Clean Water Act Section 303(d) List of Impaired Waters, 2002 Update, Regional Water Quality Control Board, October, 2001.

[17]San Diego Basin Plan, p. 2-1 (1994).

Total Maximum Daily Loads (TMDLs) must then be developed for these sites, allowing water quality-based controls to be established. TMDLs are created to ensure the restoration of beneficial uses and the achievement of water quality objectives. Once developed, TMDLs are adopted as amendments to Basin Plans.

SBPP's Designated Discharge Channel

A large section of the southeastern area of South San Diego Bay is designated as "the discharge channel." Historically, this area was treated as part of the power plant and not part of the Bay.[18] Because of this, the beneficial uses were not fully protected for waters in the discharge channel. When studies were conducted in the 1970s and 1980s they repeatedly found the plant was not significantly impacting South Bay because *"thermal effluent from the South Bay Power Plant had no major adverse effects on the benthic communities beyond the end of the cooling channel..."*[19] and *"..no significant ecological effects caused by the operation of the South Bay Power Plant at any location outside of the cooling channel."*[20]

It is also stated that at least one of these findings were true for the 1968-1973 cooling period.[21] During this period, the cooling water use was permitted for 434 MGD, far less that the 601 MGD permitted today. Even then, the studies showed that stations near the thermal effluent had *"considerably different chemical, physical, and biological characteristics than did those of all other stations."*[22]

Storm Water Permit Requirements

SBPP is regulated under the General Industrial Storm water Permit issued in 1997.[23] The new tentative permit does not include storm water requirements.

[18]Hearing transcript, RWQCB, SDG&E Permit Reissuance. June 13, 1996, p. 11.
[19]Ford and Chambers (1974) cited in Duke Application, Appendix G, p. 24.
[20]Lockheed Center for Marine Research cited in Duke Application, Appendix G, p. 24.
[21]Ford and Chambers (1974) cited in Duke Application, Appendix G, p. 24.
[22]Lockheed cited in Duke Application, Appendix G, p. 24.
[23]SWRCB Order No. 97-03.

Section 2

Environmental and Human Health Impacts from the South Bay Power Plant

A. Overview of Plant Operations

The South Bay Power Plant is an electric power generating facility. It is located at 990 Bay Blvd., Chula Vista, California, at the far southeast shore of South San Diego Bay and is surrounded by sensitive mudflat habitat. The facility has four steam turbine electrical generating units and one gas turbine generator. Each of the four steam units burns natural gas with the option of burning fuel oil during natural gas curtailment. Each of the units can generate electricity independently or in conjunction with one another, with a total rating of 737 MW.

SBPP generates electricity through a closed-cycle in which steam is produced in boilers, passed through turbines to generate electricity and then condensed to a liquid by the cooling water system before being returned to the boilers. The plant uses what is called a once-through cooling system which means that cooling water is drawn from San Diego Bay. Waste heat from the condensation of steam leaving the turbines is transferred to the cooling water in condenser tubes. This heated cooling water is then discharged to the Bay. At full capacity the amount of water used and discharged back to the Bay is 601 million gallons a day (MGD).[24] (601 MGD is the permit limit and design rate of the units. Actual usage varies according to plant operation. From 1996 to 1999 monthly average use was 513 MGD and the median was 519 MGD, with a maximum monthly average of 596 MGD.)[25] Power plants including San Onofre and the Encina Plant in Carlsbad use this cooling method, but draw from and release to the open ocean, where the volume of the water body greatly exceeds the amount of water being used, and where the heated water is much more quickly dissipated.

The SBPP energy conversion efficiency is about 38%, inefficient compared to modern day power plants which can be upwards of 56% efficient.[26] A new plant that generates the same electricity would use significantly less natural gas and emit less air pollution.

The SBPP is also the worst urban blight in the South County. Its antiquated industrial revolution appearance frustrates economic and tourism development for Chula Vista and

[24]SWRCB Order No. 96-05.

[25]Application for renewal of the NPDES permit for Duke Energy's South Bay Power Plant, EPA Form 2C, Appendix A, May 4, 2001.

[26]CEC staff report, May 2000, 99-AFC-5, p. 365.

Imperial Beach.

SBPP also uses, stores, and transports large amounts of dangerous toxic chemicals. The San Diego County Hazardous Materials Database indicates that the SBPP uses 89,000 gallons a year of sodium hypochlorite (chlorine bleach) storing 6,500 gallons at a time in above ground storage tanks.[27] Sodium hypochlorite is listed as an Immediate Health Hazard. This chemical is dangerous in storage, use, and during its transportation through communities. Even the material provided by Duke in the application for renewal warns that sodium hypochlorite exhibits aquatic toxicity and *"May seriously affect aquatic life. Do not allow spilled material to enter sewers or streams."* [28] In conjunction with chlorine, the use of sodium bromide is allowed as well but not monitored for separately.[29]

B. Biological and Ecological Impacts of the South Bay Power Plant

–By Elaine M. Carlin

Introduction

Today a generating station like the SBPP, which uses large volumes of sea water for cooling, would never be permitted to operate in the shallow, enclosed, marine environment of South San Diego Bay. Its shallow waters, dark sediments that are solar-heated, and sluggish tidal circulation make the South Bay a sensitive marine environment, highly vulnerable to heat (thermal), chemical and other pollution sources. Already in 1967, two years after it began operation, the plant was considered by the US Department of the Interior to be one of two sources of pollution in the South Bay.[30]

> *"South San Diego Bay contains a substantial proportion of the remaining examples of several critical and sensitive Southern California coastal resources–saltmarsh, intertidal and shallow-subtidal protected embayment habitats, eelgrass beds, fishery and shorebird habitats. Each of these resources has suffered very substantial historical declines, and what remains must be protected from further degradation."*[31]
>
> –Michael Branden Associates, *et al.*

[27] County of San Diego Hazardous Waste Inventory, search conducted November 5, 2001. Establishment #H 13939. A check of this number against usage reported to the Regional Board revealed lower use estimates of 57,000 gallons.

[28] GPA Industries Material Safety Data Sheet, Sodium Hypochlorite, taken from the Duke Application.

[29] Order 96-05, p. 5.

[30] Parrish and Mackenthum, 1968, *San Diego Bay. An Evaluation of the Benthic Environment. October 1967.* Biology and Chemistry Section, Technical Advisory & Investigations Branch, Federal Water Pollution Control Administration, U. S. Department of Interior, pp. 21, iv.

[31] Michael Brandman Associates, Philip Williams & Associates, Ltd., and TRC Environmental Consultants, 1990, *Preliminary Report of City of Chula Vista: (SDG&E) 89-NOI-1, p. III-4.*

The south bay environment is the most vulnerable in summer because of naturally high water temperatures. Yet in summer the plant releases the most thermal pollution (the warmest water) because of higher summer energy demands. Water temperatures discharged from the plant can reach over 100°F degrees, a lethal temperature for fishes, shellfish, and other marine life. In addition to heat, the plant releases toxic chemicals in its discharge water, including copper, nickel, zinc, and chromium (primarily from corrosion in the condenser and condenser tubing), and chlorine. Studies have shown that the high temperatures make the effects of these chemicals even more toxic to marine life, for metabolic reasons.[32]

Higher water temperatures also reduce the amount of oxygen in the water, and at the same time increase the metabolic rates of animals, which in turn increases their oxygen demand. In fact, the metabolic rate has been shown to double every 10°C (18°F).[33] Thus, animals have a higher need for oxygen but there is less available in the water. The plant further decreases the amount of oxygen in the water by discharging the dead plants, fishes, shellfish and other invertebrates, and microscopic organisms that die in the cooling water system, back into the shallow waters of the bay. These excess nutrients cause the growth of bacteria and other microscopic organisms. Their metabolic activity further decreases the oxygen supply. These organisms then die-off and the decay of the dead animals, plants and microscopic organisms take yet more oxygen out of the water.

When the power plant is running at full capacity, the plant is licensed to draw 601 million gallons of bay water into the plant each day for cooling purposes. The water is used as a heat exchange medium in the steam condensation process. This is roughly 20 percent of the water in the entire South Bay at mean sea level (601 million gallons out of 2,972 million gallons).[34] The percentage is higher at low tide and less at high tide. Fishes, shellfish and other invertebrates are drawn into the plant, trapped and killed on racks and screens. Early life stages of marine plants and animals are also drawn into the cooling water system, where they are subjected to mechanical damage, as well as chemical, temperature and pressure shock.

Biodiversity and Ecosystem Health

Ecosystems are by nature extremely complex systems in which many, many relationships exist. In addition to relationships between organisms (the food chain or web for example), there are many more chemical and physical phenomena that are involved in these relationships. Much about how ecosystems work is not yet known; however scientists have determined with some certainty that the more complex an ecosystem, the more stable it will be. As humans

[32]Richard F. Ford, personal communication, 2001; See for example, Capuzzo, Judith M., 1979, "The Effects of Temperature on the Toxicity of Chlorinated Cooling Waters to Marine Animals – A Preliminary Review," *Marine Pollution Bulletin*, Vol 10, pp. 45-47.

[33]Van't Hoff's Law.

[34]The area of South Bay is defined as extending to a line running from the Sweetwater Flood Control Channel to the Silver Strand. Merkel, Keith and Scott Jenkins, 1996, *San Diego Gas & Electric South Bay Power Plant NPDES Permit Renewal. South Bay Residence and Recirculation*, p. 2.

disturb and change ecosystems, the systems become less stable. In addition, we upset the balance of these systems, creating a myriad of changes that are impossible to predict or understand given the young stage of the ecological sciences. An important example is how we have upset the balance of atmospheric gases by the burning of fossil fuels, which is now causing global scale changes to the atmosphere and oceans.

On the much smaller scale of South San Diego Bay, there is an intricate ecosystem at work, providing essential services of many kinds. The SBPP has been disrupting the natural ecosystem for almost 40 years, since it began operating in the 1960s. Certain of these disruptions are easy to identify, but most are unknown. Almost certainly the ecosystem is less diverse, with dominant species present because of their ability to withstand the warmer water. Annual studies from 1977 to 1994 have confirmed that diversity of benthic (bottom dwelling) marine life is significantly reduced in the South Bay in areas directly affected by the plant's discharge.[35]

The dominant fish species near the plant is now the round stingray (Urolophus halleri), which is a voracious feeder on a wide spectrum of benthic animals.[36] Species that cannot withstand the high temperatures have become reduced in abundance or eliminated in the areas of the discharge. Others die off each summer. Invader species that are not native to this part of the world and that have a high temperature tolerance, such as the Japanese mussel *(*Musculiata senhousei*)* can then become established. This species has forced out natural mollusk populations in the South Bay, in other parts of San Diego Bay, and in Mission Bay, and is responsible for major damage to native ecosystems. The Japanese mussel is especially likely to take hold in disturbed habitats, such as the dredged bottoms of the power plant's intake and discharge channels.

Microbial (microscopic-level) organisms are an essential component of biodiversity. All animals and plants (and humans) are dependent on their activities. Almost certainly there is less microbial diversity in the South Bay, because bacteria and microorganisms essential for healthy and sustainable ecosystems are repeatedly exposed to chlorination and other damage (discussed below). Given the large percentage of South Bay water drawn through the plant, a significant percentage of these populations are apparently affected.

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[35]EA Engineering, Science, and Technology, 1995, *South Bay Power Plant Receiving Water Monitoring Program with Emphasis on the Benthic Invertebrate Community (1977-1994),* Prepared for San Diego Gas and Electric Company, San Diego, California.

[36]*Application for Renewal of the NPDES Permit for Duke Energy South Bay LLC's South Bay Power Plant,* 2001, Submitted to the Regional Water Quality Control Board, Appendix G, p. 13; Richard F. Ford, personal communication, 2001.

Power Plant Effects on the Water Itself

> *"Temperature changes are known to affect every physical property of concern in water quality management, including water density, state, viscosity, vapor pressure, surface tension, gas solubility and diffusion."* [37]
>
> –Majewski and Miller, p. 22

Temperature affects many of the physical and chemical properties of water, and these changes in turn have biological consequences. For example, decreased viscosity may result in increased sedimentation, which can prevent eelgrass growth.[38] Increased temperature changes chemical reaction rates, altering a multitude of biological processes, the assimilation of waste, the efficiency of waste treatment systems, and the corrosion of materials.[39] The plant also adds chemicals directly into the Bay in the cooling water, producing additional changes in water chemistry. By increasing temperature and adding excess nutrients, the plant reduces the amount of oxygen in the water. The nutrients also change biological processes and decrease the transparency of the water which can limit plant growth.

Killing of Early Life Stages of Organisms

The South Bay is widely recognized as a critically-important spawning and nursery ground for many early life stages of fishes and invertebrates, including the California halibut. It is one of the increasingly rare habitats of its type (in California, in the United States, and around the globe). Baywide, 88 percent of salt marsh habitat has been lost, and now only remains in South San Diego Bay.[40] The South Bay is also an important resting, feeding, and breeding area for a diverse community of resident and migratory shore and other water birds.[41]

The loss of early life stages of fish, shellfish and other invertebrates, and other microscopic plants and animals that form the base of the food chain/web, may affect the overall ecological balance of aquatic ecosystems.[42] These small organisms include phytoplankton,

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[37]Majewski, W. and D. C. Miller, Eds., 1979, *Predicting effects of power plant once-through cooling on aquatic systems*, A Contribution to the International Hydrological Programme, UNESCO. p. 22.

[38]*Ibid.*, p. 22; Richard F. Ford, personal communication, 2001.

[39]*Ibid.*, p. 22.

[40]U.S. Department of the Navy, Southwest Division, 1999, *San Diego Bay Integrated Natural Resources Management Plan*, Prepared by Tierra Data Systems, pp. 2-40.

[41]Ford, Richard F., *1968, Marine Organisms of South San Diego Bay and the ecological effects of Power station cooling water, A pilot study conducted for the San Diego Gas & Electric Co.*, Environmental Engineering Laboratory Tech. Rept.

[42]Clarke, J. and W. Brownell, 1973, "Electric Power Plants in the Coastal Zone: Environmental Issues." *American Littoral Society Special Publication*, Volume 7, as cited in Lawler, Matusky & Skelly Engineers, 1979, *Ecosystem Effects of Phytoplankton and Zooplankton Entrainment*, Prepared for Electric Power Research Institute (EPRI); Effer, W. R. and J. B. Bryce, 1975, "Thermal Discharge Studies on the Great Lakes – The Canadian Experience," In *Environmental Effects of Cooling Systems at Nuclear Power Plants, Proceedings of a Symposium, Oslo, 26-30 August 1974*, IAEA (Vienna), as cited in Lawler, Matusky & Skelly Engineers, *op. cit.*; Henderson,

zooplankton, fish and invertebrate eggs and larvae, and very small (juvenile) fish and invertebrates. The plant draws these organisms in (entrains them) as it draws in cooling water.

> *"One of the most important potential aquatic impacts of steam electric power plants is the mortality of organisms that are contained in the water that is drawn through the plant for condenser cooling purposes. Organisms that are small enough to pass through the plant's intake screening system are said to be entrained, and many of these organisms may be killed by exposure to mechanical, chemical, or thermal stresses during plant passage. Of particular concern are the early life stages of populations of fish and shellfish that inhabit the adjacent water body or use the area as a spawning or nursery habitat."* [43]
>
> –Boreman and Goodyear, p. iii

Due to concerns over the potential damage to the populations of these organisms, and the ecosystem balance as a whole, the electric power industry itself recommends that an entrainment impact assessment be carried out when a plant uses a large percentage of the water body.[44] Not only does the SBPP withdraw cooling water from the entire water column,[45] the plant's daily intake of water is an extraordinarily high percentage of the water body. Yet, no entrainment impact assessment has been performed for the South Bay Power Plant for over 20 years.[46]

Entrained organisms are either killed outright by the plant due to temperature, pressure and chemical shock, or come through the plant alive, but in a significantly compromised state. Many of these organisms will go through the plant multiple times because what is supposed to be "once-through" cooling is actually "many times-through" cooling. In 1980 it was estimated that approximately 31 percent of the intake water was recirculated at least once in two and a half days.[47] In 1996 it was estimated that approximately 45 percent of the discharged water was being recirculated at least once. In fact, "significant multiple recirculation appears to occur over a period of 5 days following initial entrainment of new water."[48]

This recirculation exacerbates the impacts of temperature, chemical pollution,

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P.A. and R.M.H. Sealby, 2000, *Technical Evaluation of US Environmental Protection Agency Proposed Cooling Water Intake Regulation for New Facilities,* Pisces Conservation Ltd.

[43]Boreman, John and C. Phillip Goodyear, 1978, *An Empirical Transport Model for Evaluating Entrainment of Aquatic Organisms By Power Plants,* Power Plant Project, Office of Biological Services, Fish and Wildlife Service, U. S. Department of Interior, p. iii.

[44]Lawler, Matusky & Skelley Engineers, *op. cit.*, p. S-9.

[45] San Diego Gas & Electric Co., 1980, *South Bay Power Plant Cooling Water Intake System Demonstration,* Prepared for: California Regional Water Quality Control Board, San Diego, CA, p. 4-19.

[46]The last such study was conducted in 1979-1980. *Ibid.*

[47]*Ibid.*, p. 5-4.

[48]EA Engineering, Science, and Technology, 1996, *Technical Report on Net/Gross Discharge Limits.* Final Report prepared for San Diego Gas and Electric Co., p. 6.

entrainment, excess nutrients, suspended solids, and other harmful impacts discussed throughout this paper. The problems associated with recirculation are further amplified by the sluggish circulation in South Bay. The tidal current exchange process is quite slow, tending to isolate this region from the rest of the bay.[49] In the "*near field*" area (the body of water under direct influence of the plant) ebb directed flow is never strong enough to counteract intake water withdrawal.

A study was conducted in 1979-1980 to evaluate the impacts of the SBPP intake system, in order to *affirm or disprove its designation by the State as a "high impact" plant.* Study results were also used to determine *whether the intake design reflects the best available technology to minimize adverse environmental impacts.*[50] The SBPP had been designated by the state as a "high impact" plant based on the location of its intake in an

> *" ...area of very high value aquatic habitat."* [51]
>
> –San Diego Gas & Electric Co., 1980, p. 4-3

The entrainment of organisms in the SBPP was found to exert a negative influence on the marine animal communities during most of the year. The near field area was found to have a different zoological plankton community, as compared to the rest of the bay, in terms of species composition and abundance.[52] Most critical zooplankton taxa were significantly lower in number than those found at stations located away from the plant's influence. Only one species was higher in abundance in the near field.

The study also found that, in general, the near field environment was biologically different than the remainder of the bay with certain species preferring to spawn in this area, while others were absent (apparently either avoiding the region or killed off in this area). The study suggested high power plant recirculation rates may be partly responsible for the lower abundance, as may the harsh physical conditions of high turbidity, slow flushing, and temperature and salinity extremes.[53]

Effects on phytoplankton were documented by measuring differences in the chlorophyll a of the microscopic plants. Chlorophyll a concentration decreased by as much as 88 percent after the plankton passed through the plant in summer, and by 28 percent in winter.[54] Plankton killed by the plant was estimated to be less than one percent of the total bay's plankton community.[55]

To determine the impact of entrainment losses, estimates of the number of organisms

[49]San Diego Gas & Electric Co., *op. cit.*, p. 5-4
[50]*Ibid.*, pp. 4-1, 4-2
[51]*Ibid.*, p. 4-3
[52]*Ibid.*, p. 10-28
[53]*Ibid.*, p. 10-37
[54]*Ibid.*, p. 9-3
[55]*Ibid.*, 1980, p. 9-3

killed by the plant were compared to the total population of these organisms in the bay. In order to determine total bay population size, the average densities of organisms found at the sampling stations were multiplied by the volume of the bay. This method resulted in very large population numbers. Even so, the percentage of the populations of various species killed by the plant in 1979 ranged from less than 1 percent of the population to 28 percent of the population for goby-types fishes during peak entrainment.[56] As one example of the potential ecological impacts of these losses, gobies are believed to be an important food source for young tern chicks.[57]

One method used to analyze the importance of entrainment of fish eggs and larvae is to estimate the number of adults which would have resulted from the entrained larvae.[58] Although the method provides little insight into the long term viability of the affected populations, it can be used to obtain a first approximation of the severity of potential losses. The 1979-1980 study estimated loss using such a method and found that the plant killed 8 million gobiids (goby-type fishes) in 1979, 240,000 anchovies, and 42,000 topsmelt.[59] At the time, these numbers were considered to represent an acceptably low impact. Based on this finding, and a low impact finding for impingement (discussed below), the SBPP's designation as a high impact plant was changed to "low impact."[60] Because the plant's impact was determined to be low, it was assumed that the technology used at the time was the best technology available.

Because the natural community of plankton and early life stage organisms was not documented before the plant began operating, we do not know the cumulative, long-term effects of the damage to these populations. Obviously there is a huge impact to south bay plankton and early life stages of organisms, with up to 20 percent (at mean sea level) of the South Bay's water moving through the plant at least once per day. Most of the organisms present today apparently come in with the tide from other parts of the bay. Enhancements to the south bay environment to protect this rare habitat, and increase its productiveness, would appear to be quickly counteracted by the plant's huge influence on what should be a critical nursery ground.

Trapping and Killing of Fishes and Large Invertebrates

Adult fishes and invertebrates in the vicinity of the intake are drawn into the plant intake structure and are trapped (impinged) by either a "trash rack" or by a series of screens. Fishes that are attracted by the heated discharge water or take refuge in the area during storms may also become impinged due to the proximity of the intake to the discharge channel. The

[56] *Ibid.*, p. 10-38.

[57] Gilbert, N., US Fish and Wildlife Service, June 6, 2001, Letter to J. Robertus, Regional Water Qualtiy Control Board.

[58] Goodyear, C. Phillip, 1978, *Entrainment Impact Estimates Using the Equivalent Adult Approach*, Power Plant Project, Office of Biological Services, Fish and Wildlife Service, U.S. Department of the Interior, p. 1.

[59] San Diego Gas & Electric Co., *op. cit.*, p. 10-49.

[60] *Ibid.*, p. 10-1.

dominant species observed at the San Onofre Power Plant outfall, for example, were also those found to suffer the highest rates of entrapment in the intake system.[61]

Despite wide acknowledgment that impingement is a major source of power plant impacts, no study has been conducted to address this impact for the last 20 years. The only recent fish-related study of the south bay plant is a report on fishes that are found in the discharge channel.[62] This study does not address the millions of larval fishes and tens of thousands of adult fishes that are drawn into and die in the plant each year.

The 1979-1980 study (discussed above) considered impingement and estimated that 28,174 individual fish were killed in the plant in 1979. The most commonly impinged species were the round stingray, topsmelt, two species of anchovies, the specklefin midshipman, and the Pacific butterfish.[63] The numbers of fish impacted were considered to be insignificant when compared to the total population of these fish species in San Diego Bay. If the "source water resource" was considered to be the South Bay rather than the entire bay, then the percentage of the population killed would be much higher. Impingement losses were also compared to commercial fishing takes and natural losses.

The effect of these types of environmental impacts do not necessarily diminish with distance from their source[64] and there may be time lags before the impact occurs.

> *"Entrainment and impingement losses may affect ecosystems many miles from the power plant, particularly when species are migratory. Similarly, time lags in response may mask severe impacts."* [65]
>
> –Fritz *et al.*, p. 20

Killing of Clams, Mussels, and Other Organisms That Inhabit the Bottom (Benthic) Environment

Operation of the power plant kills benthic life in the discharge channel. This has been an established fact since the first studies of the plant's effects were conducted in the late 1960s and early 1970s.[66] At that time and until very recently (1997) the discharge channel was not

[61]Tetra Tech, Inc., 1977, Unpublished, as cited in Thomas, *et al., The Effects of Thermal Discharges on Fish Distribution and Abundance in the Vicinity of the San Onofre Nuclear Generating Station,* Final Report to the Marine Review Committee, p. 12.

[62]Merkel and Associates, Inc., 2000, *South Bay Power Plant Cooling Water Discharge Channel Fish Community Characterization Study,* Final Report, Prepared for Duke Energy South Bay LLC.

[63]San Diego Gas & Electric Co., *op. cit.*, p. 7-2.

[64]Holling, 1978, as cited in Fritz et al, 1980, *Strategy for Assessing Impacts of Power Plants on Fish and Shellfish Populations,* Power Plant Project, Office of Biological Services, Fish and Wildlife Service, U.S. Department of the Interior, p. 20.

[65]Fritz *et al.*, *op. cit.*, p. 20.

[66]Ford, 1968, *op. cit.*, Ford *et al.*, 1970, *Ecological effects of power station cooling water in South San Diego Bay during August 1970,* Prepared for the San Diego Gas & Electric Co., Environmental Engineering

considered by the power plant or the regulatory authority as part of the Bay, even though this channel "incorporates many acres of prime biological shallow water and intertidal habitat."[67] Instead this part of the Bay was defined as part of the plant. For this reason, studies up until 1997 could conclude that there were "no significant impacts" from the plant on benthic life.

Dissertation research on two types of clams illustrates the toxicity of temperatures in the discharge channel. In 1981, Merino found that the heated discharge from the plant affected the distribution, growth, and reproductive characteristics of the California jackknife clam (<u>Tagelus</u> <u>californianus</u>) and the pencil clam (<u>Solen</u> <u>rosaceus</u>).[68] The pencil clam could only survive at a distance of more than 2100 meters from the point of discharge; the jackknife clam could survive beyond 750 meters, and only by buffering itself in the sediments.[69] Clams surviving in the discharge channel beyond these distances were found to grow faster, but to have more variable reproductive effort, fewer young, and shorter life spans, while clams inhabiting areas away from the increased temperatures of the discharge channel had a more predictable breeding cycle resulting in numerous young, longer life spans, and larger ultimate size.[70]

Sea Turtles

It is believed that sea turtles were residing in San Diego Bay long before human settlement. Today the Bay supports a population of turtles, roughly estimated at 30 to 60 individuals. Over 30 have been tagged over a ten year period.[71] Turtles also occur in Mission Bay, and are known to associate with power plants north of San Diego.[72] With the use of genetic information, these turtles have now been identified as green turtles (<u>Chelonia</u> <u>mydas</u>) belonging to a Mexican subpopulation.[73] The green turtle population has crashed due to

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Laboratory Tech. Rept.; Ford *et al.*, 1971, *Ecological effects of power station cooling water in South San Diego Bay during February-March 1971,* Prepared for the San Diego Gas & Electric Co., Environmental Engineering Laboratory Tech. Rept.; Ford *et al.*, 1972, *Ecological effects of power station cooling water in South San Diego Bay during August 1972,* Prepared for the San Diego Gas & Electric Co., Environmental Engineering Laboratory Tech. Rept.; Ford, R.F., and R.L. Chambers, 1973, *Thermal Distribution and biological studies of the South Bay Power Plant,* Prepared for the San Diego Gas & Electric Co., Environmental Engineering Laboratory Tech. Rept.; Ford, R.F., and R.L. Chambers, 1974, *Thermal distribution and biological studies for the South Bay Power Plant,* Prepared for the San Diego Gas & Electric Co., Environmental Engineering Laboratory Tech. Rept.

[67] Michael Brandman Associates, *et al., op. cit., p. III-15.*

[68] Merino, Jose-Maria, 1981, *A Study of the Temperature Tolerances of Adult <u>Solen</u> <u>rosaceus</u> and <u>Tagelus</u> <u>californianus</u> in South San Diego Bay: The Effects of Power Plant Cooling Waste Discharge,* A Dissertation, San Diego State University/University of California Riverside, p. 3.

[69] *Ibid.*, p. 110-111.

[70] *Ibid.*, p. 121.

[71] Peter Dutton, personal communication, 2001.

[72] McDonald *et al.*, 1994, *A Review of the Green Turtles of South San Diego Bay in Relation to the Operations of the SDG&E South Bay Power Plant, Doc 94-045-01,* Prepared for San Diego Gas & Electric Co., San Diego, CA, p. 10.

[73] Peter Dutton, personal communication, 2001.

enormous taking (killing) of these turtles in the lagoons of Mexico where they feed (foraging grounds), and is now considered endangered throughout most of its range.[74] Because the waters of South Bay are naturally warm due to shallow depths, it is expected that turtles would continue to come to San Diego bay to feed in the absence of the power plant.[75]

Halibut

The California halibut (<u>Paralichthys</u> <u>californicus</u>) is important to the ecology and fisheries of southern California. Its population may be threatened by the development of embayments used as nursery habitats. It appears that temperature, turbulence, and sediment characteristics (related to turbulence) are important factors determining whether juvenile halibut will settle in an area. Juveniles tend to be found in areas with higher oxygen concentrations[76] and settlement of halibut has been found to decrease rapidly above 22ºC (72ºF).[77]

A study of the distribution of juvenile halibut revealed that there are many fewer juveniles in San Diego Bay (13,759) as compared to Mission Bay (22,082), yet San Diego Bay is approximately five times the area of Mission Bay.[78] The density in shallow water habitats (less than 1 meter in depth) was found to be 21 per hectare in Agua Hediona, 66 per hectare in Mission Bay, and less than 1 per hectare in San Diego Bay.[79]

Impacts of Chlorine on Marine Life

The South Bay Power Plant uses chlorine in the form of sodium hypochlorite daily to kill plants and animals that would otherwise grow on the cooling water system piping or other surfaces. The use of chlorination in once-through cooling systems has been questioned since at least 1979.[80] Almost all species of animals are hit hard by chlorine. This effect is exacerbated in a shallow, poorly circulated environment like the South Bay. Valves in the plant are designed to automatically release chlorine for a total of 80 minutes every four hours, but may periodically become stuck open. A stuck valve means that chlorine is being continuously released; this may be one explanation for fish kills reported in the area of the SBPP.

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[74] McDonald *et al.*, *op. cit.*, p. 9.

[75] Peter Dutton, personal communication, 2001.

[76] MBC Applied Environmental Sciences, 1992, *Distribution of Juvenile California Halibut (Paralichthys Californicus) in Bay and Coastal Habitats of Los Angeles, Orange, and San Diego Counties in 1992.* Final Report, p. 1, viii.

[77] MBC 1991b, as cited in *ibid.*, p. 1.

[78] Kramer, Sharon Hendrix, 1990, *Habitat Specificity and Ontogenetic Movements of Juvenile California Halibut, <u>Paralichthys</u> <u>californicus</u>, and Other Flatfishes in Shallow Waters of Southern California,* A Dissertation, University of California, San Diego, p. 61; Kramer, S. H., "Distribution and Abundance of Juvenile California Halibut, <u>Paralichthys</u> <u>californicus</u>, in Shallow Waters of San Diego County," p. 119, listed in *The California Halibut, <u>Paralichthys</u> <u>californicus</u>, Resource and Fisheries* edited by Charles W. Haugen, 1990.

[79] Kramer, S. H., 1997, Memorandum to Laura Hunter, Environmental Health Coalition.

[80] Majewski and Miller, *op. cit.*, p. 22.

In addition to its immediate effects, chlorine is now known to break down, complex with other substances, and form new compounds such as chlorinated organics.[81] These chlorinated organic compounds can remain toxic for aquatic life for long periods.[82] Sublethal effects of free and combined chlorine on fish, invertebrates, and other marine organisms need to be assessed for the SBPP discharge, and factored into regulatory limits.[83] Chlorinated cooling waters have been found to cause significant sublethal stress to some organisms, so that measurements of surviving organisms underestimate chlorine toxicity.[84] Low-levels of chlorination, dechlorination of water, and rapid dilution of cooling water discharge are recommended to protect marine life.[85] Yet the SBPP uses significant amounts of chlorine (see below), does not dechlorinate, and rapid dilution is impossible in the shallow waters of South Bay (unlike power plants on the coastal ocean where dilution is rapid, and the intake and discharge water volumes represent a small percentage of the overall water body).

The plant uses more chlorine in summer, compounding the effects of higher summer water temperature, less dissolved oxygen, and the greater toxicity of other chemicals. In 1980 it was reported that to produce the (then) seven minute injections of chlorine, a maximum of 233 pounds of chlorine was injected per 24 hours in the winter, and 653 pounds in the summer.[86] More recently, the SBPP reported use of 4119 pounds of chlorine during the month of August, 2001.[87] We know little of the concentration of chlorine in the cooling water released by the plant, and how these concentrations fluctuate, because the plant only tests the discharge water for chlorine twice monthly, and uses a "grab" water sample to test, rather than using a continuously-plotting analyzer. These major problems with the plant's monitoring for chlorine have been raised by the regulatory authority:

> *"Here is a pollutant that SDG&E intentionally puts into cooling water several times daily for purposes [of] killing marine organisms yet monitoring is required only twice a month, during one chlorination cycle, when the SDG&E thinks the concentrations are likely to be highest, by means of grab samples."* [88]

> *"The more I think about the current requirement for monitoring chlorine by means of twice monthly grab samples, the more inadequate and ridiculous that seems to me, given (a) the intermittent nature of chlorine discharges, (b) the likely fluctuations in effluent chlorine concentrations and (c) the relationship between the chlorine limit and the duration of uninterrupted chlorine discharge. That thought is reinforced when I learn*

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[81]Jolley, R. L. 1975, "Chlorine-containing organic constituents in sewage effluents," *J. Water Poll. Control Fed.*, Vol. 47, p. 601-618, as cited in Majewski and Miller, *op. cit.*, p. 22.

[82]Gehrs *et al.*, 1974, "Effects of stable chlorine-containing organics on aquatic environments." *Nature*, Vol. 249, p. 675-676, as cited in Majewsi and Miller, *op. cit.*, p. 22.

[83]Capuzzo, Judith M. *et al.* 1977, "Chlorinated Cooling Waters in the Marine Environment: Development of Effluent Guidelines," *Marine Pollution Biology*, Vol. 8, No. 7, p. 161-163.

[84]*Ibid.*, p. 162.

[85]*Ibid.*, p. 163.

[86]San Diego Gas & Electric Co., *op. cit.*, p. 3-9.

[87]San Diego Regional Water Quality Control Board staff, personal communication, 2001.

[88]Email from B. Posthumus, RWQCB, to J. Richards, SWRCB, Sept. 7, 1998.

that SDG&E's self monitoring reports apparently typically specify the duration of uninterrupted chlorine discharge to be 20 minutes, although in our discussions with SDG&E and in their consultant's proposed chlorine limit report, a figure of 80 minutes (4 units at twenty minutes each, one right after the other) was used. Chlorine really should be measured by means of a continuously recording/plotting analyzer." [89]

"I should have realized that there is no incentive for SDG&E to use a more sensitive analytical method which would actually produce reliable measurement at level at or nearer the concentrator limits. Such a method might actually reveal noncompliance! If you use a yard stick you conveniently can't measure those small fractions of an inch...insensitive analytical methods can nullify numerical limits intended to protect sensitive critters..." [90]

–Regional Water Quality Control Board, staff correspondence

A consultant to the power company has suggested that the ability of species to avoid chlorine exposure by temporarily retreating into their shells means they can actively avoid exposure under intermittent chlorine programs.[91] This suggestion points up the toxicity of chlorine to marine organisms. Moreover, according to the consultant, more mobile forms will actively avoid chlorine concentrations in the discharge vicinity but can still utilize all habitat during the unchlorinated periods.[92] It is unclear how these mobile forms would time their use of this habitat according to the plant's chlorination cycle. Furthermore, according to the consultant, the flushing of plankton forms by tidal action and the unchlorinated plant flow in the intervals also reduces exposure of free floating organisms.[93] Again, this suggestion speaks to the risk of exposure to chlorine. Tidal flushing in South Bay is sluggish at best.

Impacts of the Release of Copper and Zinc into the Bay

The SBPP releases an estimated 400-1020 pounds of copper (a heavy metal which is highly toxic to marine life and known to accumulate in fish and shellfish) into the Bay each year.[94] Nickel concentrations in the cooling water have also been significant.[95] In addition, zinc waste plates, used for corrosion control, release zinc into the cooling water.[96]

[89]Email from B. Posthumus, RWQCB, to P. Husby, EPA, Aug. 28, 1998.

[90]Posthumus, *op. cit.* Sept. 7, 1998.

[91]Applied Science Associates, 1988, *Proposed Effluent Limit for Residual Chlorine for the South Bay Power Plant* (This document is labeled : "For settlement purposes only."), p. 6.

[92]*Ibid.*

[93]*Ibid.*

[94]SPAWARSYSCEN San Diego, 1999, *Cooling Water System Copper Study,* Final Report, p. 10.

[95]San Diego Regional Water Quality Control Board staff, personnel communication, 2001.

[96]California Regional Water Quality Control Board, San Diego Region, *Fact Sheet, Tentative Order No. 2001-283, Waste Discharge Requirements, South Bay Power Plant,* p. 7.

Copper concentration in the cooling water measured at a power plant in California was 1,800 micrograms per liter after a plant shutdown, when water sat in contact with copper-nickel tubing of the cooling water heat exchange system. This initial concentration was rapidly diluted, however even after 30 days, copper concentration in the cooling water discharge was 20 micrograms per liter.[97] Researchers reported that 1500 abalone were killed in this instance. Laboratory studies show 30 to 65 micrograms per liter of copper to be lethal to adult organisms after 96 hours of exposure for the two species tested.[98]

Copper concentrations reported in the cooling water of the SBPP were 25.7 micrograms per liter in routine monitoring required by EPA. The plant sampled over a 24 hour period in December 2000. The power plant's report states that this level is abnormally high because of "weather conditions" described as rain and choppy water conditions (which according to the report, likely stirred up the bottom of the channel and produced runoff from storm drain channels).[99] In contrast, the report indicates that measurements taken in January showed no detectable concentration of copper. As yet another example of the complexity of ecosystems, and the biological, chemical and physical processes involved, copper joins with organic material in the bay water to form additional forms of copper with different behaviors and effects.

For fishes, a decrease in oxygen levels of the water increases the apparent toxicity of zinc and copper.[100] Water temperature is possibly the most important factor affecting zinc toxicity, the higher the temperature, the shorter the survival time.[101] The juvenile inhabitants of South Bay are more sensitive to these metals than adult animals. Effects of zinc on fish populations and communities may be subtle and difficult to evaluate. Sublethal effects influence behavior, and concentrations far below the lethal level have been shown to decrease fish growth rates, and to reduce reproductive potential. The tendency of fishes to bioaccumulate zinc is variable–when bioaccumulation occurs, the metal is concentrated mainly in the liver, kidney, and digestive tract.[102] Accumulation of copper by the American oyster in the vicinity of a power plant has been documented where body burdens were measured as high as 1.28 mg/g dry weight within the cooling water discharge channel.[103] Another researcher found summer high values of 482 ppm of zinc and 80 ppm copper in oysters from the

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[97]Martin, M. *et al.*, 1977, "Copper toxicity experiments in relation to abalone deaths observed in a power plant's cooling waters," California *Fish and Game,* Vol. 63, p. 95-100, as cited in Majewski and Miller, *op. cit.*, p. 39.

[98]*Ibid.*

[99]*Application for Renewal*, op. cit., EPA Form 2C Section, p. 1.

[100]Lloyd, 1960, and Lloyd and Herbert, 1962, as cited in Weatherley, Alan H., *et al.*, "Zinc Pollution and the Ecology of the Freshwater Environment," In Nriagu, Jerome O., Ed., *Zinc in the Marine Environment; Part I: Ecological Cycling.* John Wiley and Sons, New York, p. 377.

[101]*Ibid.*

[102]Weatherley, Alan H. *et al.*, *op. cit.*

[103]Roosenburg, W.H., 1969, "Greening and copper accumulation in the American oyster, Crassostrea virginica, in the vicinity of a steam electric generating station," *Chesapeake Sci.*, Vol 10, pp. 241-252, as cited in Majewski and Miller, *op. cit.*, p. 39-40.

discharge. Intake canal oyster concentration in comparison were 138 ppm for zinc and 9 ppm copper.[104]

The SBPP reports the amount of copper released as the difference between the amount of copper in the intake water, and the amount of copper in the discharge water. But as discussed above, approximately 45 percent of the water entering the plant is recirculated at least once from the discharge channel. By allowing the plant to assume the copper in the intake water did not originate from the plant, the impact of copper from the plant on the Bay is greatly underestimated.

Eelgrass

Eelgrass (Zostera marina) forms a distinct marine habitat providing vital shelter and food for many bay inhabitants. The South Bay contains the vast majority of eelgrass living in San Diego Bay. For some reason, eelgrass is absent in the vicinity of the plant, yet plentiful west of the plant and in other areas of the South Bay. Eelgrass is highly dependent on sufficient light to thrive,[105] and declines in seagrass abundance have been linked to decreasing water transparency.[106]

The SBPP influences the amount of available light in a number of ways. First, by dredging the intake and discharge channels, the plant has created depths without sufficient light for eelgrass. Second, the discharge increases turbidity of the water which decreases light. Third, the discharge contains 20 percent more suspended solids than the intake water;[107] these solids block light and can deposit on eelgrass leaves where light is required at the plant-leaf surface. Fourth, the plant is increasing the amount of nutrients in the water (as discussed in other sections of this paper), which reduces water transparency.

Without the power plant discharge, we would expect a resurgence of eelgrass beds.

> *"Any enhancement of seagrass productivity through improved water quality will lead to improved growth, successful reproduction and an increase in the overall coverage and distribution of seagrasses. In turn this will enhance the fish, shellfish and wildlife resources dependent on seagrass habitat for food and shelter and improve shoreline and benthic stability..."* [108]

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[104]Grimes, C.B., 1971, "Thermal addition studies at the Crystal River steam electric station," *Professional Paper Series*, No. 11, Florida Dept. Nat'l. Resour. Res. Lab., St. Petersburg, FL., p. 53, as cited in Majewski and Miller, *op. cit.*, p. 40.

[105]NOAA, 1991, *The Light Requirements of Seagrasses*, Results and Recommendations of a Workshop, Technical Memorandum NMFS-SEFC-287.

[106]*Ibid.*, p. 5; See also Backman, T.W, and D.C. Barilotti, 1976, "Irradiance reduction: effects on standing crops of the eelgrass *Zostera marina* in a coastal lagoon," *Marine Biology* 34:33-40.

[107]*Application for Renewal, op. cit.*, Appendix F, p. 5.

[108]NOAA, *op. cit.*, pp. 6-7.

Metals and chlorine released by the plant (discussed in other sections of this paper) may also be impacting eelgrass where present, and the absence of eelgrass near the plant. Changes in sediment composition produced by the plant may also render the sediments unsuitable for eelgrass, which requires a moderate amount of grain.[109]

A study to determine the effects of the cooling water discharge on eelgrass distributions was required as a condition of the plant's most recent permit renewal.[110] This study was required based on

> *"...the observed lack of eelgrass within the central portion of south bay in apparent synonymy with the measurable limits of the power plant thermal discharge plume."*[111]
>
> –Merkel and Associates, Inc., *Environmental Controls*, p. 1

The study determined that light environments appear to control the presence of eelgrass although "many of the specific factors dictating the light environment are not fully quantifiable and in many instances may interact with each other."[112] Findings suggest that light transmission is strongly related to suspended particulate material.[113] As discussed above, the power plant increases suspended solids, and thus water turbidity, by 20 percent.

C. Air Quality Impacts from Emissions from the South Bay Power Plant

Emissions from the South Bay Power Plant

The SBPP is primarily a natural gas burning plant, though it can run on oil when natural gas supplies are curtailed. Natural gas plants are often called "clean-burning", which is not an accurate description. While natural gas certainly burns clean**er** than oil and coal, natural gas plants still pollute the air with significant quantities of nitrogen oxides (NO_x), particulate matter (PM), other criteria pollutants, and toxic air contaminants (TACs).

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[109]Richard F. Ford, personal communication, 2001.

[110]Merkel & Associates, Inc., 2000, *Environmental Controls on the Distribution of Eelgrass (Zostera marina L.) in South San Diego Bay: An assessment of the Relative Roles of Light, Temperature, and Turbidity in Dictating the Development and Persistence of Seagrass in a Shallow Back-Bay Environment.*

[111]*Ibid.*, p. 1.

[112]*Ibid.*, p. 2.

[113]*Ibid.*, p. 10.

Air pollutants are classified into two basic regulatory categories, criteria pollutants and Toxic Air Contaminants (TACs). Criteria pollutants were chosen for a special regulatory structure because there was well-documented evidence (criteria) of the health risks posed by these pollutants.

The criteria pollutants that are of primary concern from the South Bay Power Plant are nitrogen oxides and particulate matter, of a size 10 microns or less (PM_{10}) and 2.5 microns or less ($PM_{2.5}$), though other criteria pollutants may be of concern under certain conditions. When burning natural gas, the SBPP emits 3.1 tons (6,200 pounds) a day of NO_X and 0.8 tons (1,600 lbs.) a day of PM_{10} at peak generation.[114]

NO_x are of concern primarily as precursors to ozone (smog). Ozone has been linked to asthma, reduced lung development in children, and other adverse health impacts. San Diego is classified as non-attainment-serious for ozone at the federal and state levels, meaning that San Diego violates both federal and state air quality standards.

Particulate matter (PM_{10} and $PM_{2.5}$) aggravates and may cause asthma and other respiratory illnesses and has been linked to premature death among the sick and elderly. San Diego is classified as non-attainment for PM_{10} at the state level, and has yet to be classified for $PM_{2.5}$ at the federal or state levels. Particulate matter can travel as a regional pollutant but can also have significant localized impacts.

Emissions under natural-gas curtailment

The SBPP is a dual-fuel plant, meaning that it can run on oil when natural gas supplies are cut off. During the year prior to April 2001, natural gas supply was curtailed to the South Bay Plant on 14 days. When burning oil, the SBPP can emit over two times more NO_x, three times more particulate matter, 400 times more SO_x (sulfur oxides), and far greater quantities of TACs.[115] Oil burning by power plants can also result in emissions of highly toxic dioxin.[116]

D. Environmental Justice Impacts of Power Plants in South Bay Area

In the wake of the energy crisis, there is a serious concern that the press to build power plants to offset the energy demand is resulting in low income and communities color bearing a disproportionate burden of impacts of these plants. In a study that examined the recent siting

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[114]Steven Moore. San Diego County Air Pollution Control District. Testimony on behalf of APCD before the Public Utilities Commission per an "Order Instituting Investigation into the Adequacy of the SoCalGas' and San Diego Gas & Electric Company's (SDG&E) gas transmission systems to serve the present and future gas requirements of SDG&E's core and non-core customers" April 25, 2001. p. 8.

[115]*Ibid.*, p. 8.

[116]EPA Sector Notebook, Profile of the Fossil Fuel Electric Power Generation Industry, Sept., 1997, p. 67.

of power plants in California, 89% of plants studied were sited in areas that contained over 50% people of color within six miles of the plants.[117] Latinos were particularly over-represented in communities where power plants were sited.

According to the study, low-income communities were targeted for power plant siting. For 83% of the plants, the average household income was less than $25,000 per annum among the population living within six miles of the facility.[118] Locally, a peaker power plant proposed by Ramco Inc., in Chula Vista was sited near a community that is 77.3% Latino. In addition, new power plants have been proposed in Baja California, Mexico that will impact the San Diego/Tijuana air basin. Of power plants of which construction has begun or been completed over the past year in San Diego County, many are located in the South Bay Area, including Otay Mesa, which has raised concerns about this area bearing a disproportionate burden of new power plant development in San Diego.[119] In Otay Mesa, the 90 MW Wildflower Larkspur Peaker Plant was built last summer, and the 500 MW Otay Mesa Generating Project and the 49 MW Calpeak Border Peaker are under construction. In Chula Vista, a 49 MW facility owned by PG&E is under construction.[120] The community living in a six mile radius of the SBPP is 77% Latino and people of color, with 14.6% living below the poverty level.[121]

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[117] Latino Issues Forum. *Power Against the People?: Moving Beyond Crisis Planning in California Energy Policy*, November 13, 2001, p. 5.

[118] *Ibid.*, p. 5.

[119] *Comments on RAMCO Chula Vista II Peaker Generation Station (01-EP-3);* City of Chula Vista comment letter to the California Energy Commission, June 11, 2001, p. 1.

[120] California Energy Commission web site. Status of all Projects. <http://www.energy.ca.gov/sitingcases/status_all_projects.html> Accessed Nov. 19, 2001.

[121] 2000 census data (ethnicity); 1990 Census Data (poverty level). This % compares with 11.3% poverty level for the county. The 2000 poverty levels are not available.

Section 3

Environmentally Preferable Alternatives to once-through cooling

There are essentially three methods of cooling a power plant: wet-cooling (once-through and closed-cycle) and dry-cooling. Fortunately, there are feasible, viable, and protective alternatives to the once-through cooling currently used by SBPP. These are discussed below.

A. Overview: Wet-cooling: once-through and closed-cycle

Wet-cooling systems can be **once-through** or **closed-cycle**[122] systems. Both wet-cooling systems are water intensive.[123] In once-through cooling, water is taken from a local body of water, passed through steam condensers, heated up, then discharged back to the waterbody. As previously discussed, this method is environmentally devastating in a sensitive marine environment like South San Diego Bay.

Another type of cooling system is "closed-cycle"or use of evaporative cooling towers. It involves significant reuse and recirculation of cooling water. In a cooling tower system, water is circulated through the towers to transfer heat to the air through evaporation. Closed-cycle results in a unsightly steam plume and particulate matter emissions to the air. In wet-cooling systems, the heat is removed from the cooling water by being evaporated off in cooling towers. Towers are used to transfer the heat to the air through evaporation. This kind of system also has significant impacts. There are air quality impacts in that the evaporated water results in emissions of PM_{10} particulates although most particulate emissions are the salts and minerals and not the combustion by-products that are of more concern for human health.[124] A 500 MW plant with a cooling tower emits 30 tons a year of PM_{10}.[125] They require significant use of water (2-3,000 acre feet of water a year for 500 MW plant) to replace water lost to evaporation in the cooling towers ("make-up" water) and still produces thermal discharges to the bay. Cooling towers are also large, unsightly, and the evaporation emits a large visible, unattractive plume.

[122]We recognize that "closed" system is a misnomer because in all cases, heat leaves the cooling system. However, this is a common usage term for this type of system.

[123]Tellus report, pp. 2-3.

[124]Personal Communication, M. Layton, CEC, November 11, 2001.

[125]Position Paper: Environmental Impacts and Sustainable Solutions for New Power Plants in the U.S.-Mexico Border Region; Border Power Plant Working Group, August 22, 2001, p. 7.

B. Dry-cooling: The Better Option

Dry-cooling of steam turbine condensate has been available for more than 40 years and has been used in all climates. For example, a large number of dry-cooled plants are located in the arid regions of Mexico and the United States.[126] Dry-cooling is recommended by the World Bank for all climatic conditions due to the inherently "sustainable" nature of the technology from the standpoint of water resource use.[127]

Dry-cooling **uses air instead of water to cool the low-pressure steam leaving the steam turbines.** Large radiator-type tube banks are used to transfer heat from the condensing steam to air passing over the tubes. Large diameter axial fans are located under the tubes and force large quantities of air through the tube banks via a boiler feedwater pump. Dry-cooling has no air or water polluting emissions. There is no water evaporation, no visible plume, no thermal discharges, and no particulate air emissions.[128] Dry-cooling results in a small loss in plant thermal efficiency at high ambient temperatures compared to wet-cooling. For example, the overall plant thermal efficiency of the air-cooled Otay Mesa Power Plant is about 2% less on an annual basis compared to a hypothetical wet-cooled alternative, primarily due to the high summertime temperatures at the inland plant site location. There would be virtually no difference in the performance of a wet- or dry-cooled plant located on San Diego Bay in a perpetually temperate, humid micro-climate. Some or all of any efficiency loss would be counterbalanced by the capital costs, parasitic energy loads, and maintenance costs of wet-cooling auxiliary systems. For once-through wet-cooling systems these loads and costs include the energy necessary to move massive quantities of water through the cooling circuit and the cost of biocides and corrosion inhibitors to protect cooling system hardware. For evaporative wet-cooling systems, these costs include:

- Capital cost of civil works infrastructure to transport raw water to plant site
- Capital cost of wet-cooling tower <u>and</u> condensing plant
- Pump energy to move water to plant site
- Raw water
- Capital cost of raw water treatment civil works and mechanical infrastructure (if necessary)
- Raw water treatment (if necessary)
- Water treatment solids generation and disposal
- PM_{10} emissions from cooling tower(s) – emission reduction credit cost

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[126]Position Paper: Environmental Impacts and Sustainable Solutions for New Power Plants in the U.S.-Mexico Border Region, Border Power Plant Working Group, August 22, 2001, p. 7.

[127]*Ibid.*, Border Working Group Position paper, p. 7.

[128]*Urgent Need for Bilateral Agreement Between the United States and Mexico Regarding Sustainable Environmental Requirements for New Power Plants in the Border Region;* letter from Border Power Plant Working Group to The Honorable Colin Powell and Dr. Jorge Castaneda *et al.*; August 22, 2001; p. 3; Tellus Report, pp. 6-7.

- Capital cost of cooling tower blowdown treatment civil works and mechanical infrastructure
- Cooling tower blowdown (wastewater) treatment
- Capital cost of evaporation ponds for cooling tower blowdown (if used)
- Cooling tower blowdown treatment solids generation and disposal[129]

The air cooled Otay Mesa Power Plant sacrifices about 2% efficiency due to cooling.[130] Water is only needed for periodic system maintenance and cleaning. Dry-cooling could result in reductions in water use by over 99% over once-through wet-cooling and over 95% over closed-cycle wet-cooling.[131]

Two additional factors are present to further reduce and eliminate fish and marine life impacts. First, the relatively minuscule volumes of water required by dry-cooling allow for lower intake velocities, smaller intake structures, and other factors that reduce impacts. Second, the amounts of water are so low that other water supplies, such as reclaimed water, can be substituted for the biologically rich bay water.

Dry-cooling uses no chlorine or chlorine products

Another significant advantage of dry-cooling is that it does not need to sterilize the water it uses for cooling. The current, massive amount of sodium hypochlorite (chlorine) used to sterilize the once-though cooling water is completely avoided. This removes the need for up to 89,000 gallons of chlorine per year to be stored on site and transported through neighboring communities. Chlorine products are also very damaging to the environment during their manufacture and these impacts, too, are avoided through the use of dry-cooling.

Other advantages of Dry-cooling

Dry-cooling is desirable for other, non-ecological reasons. Because the system allows siting flexibility (i.e. does not need to be located on a body of water) a plant need not usurp valuable bayfront property. Such facilities can be located on difficult to develop sites.

Further, permitting issues are greatly reduced with dry-cooling and will allow a plant to be permitted, built, and processed more quickly. Several power developers have found that by using dry-cooling they can move more rapidly through federal and state permitting processes, getting energy to market more quickly.[132] Dry-cooling will enjoy a higher level of community

[129]Personal communication (email), Bill Powers, Powers Engineering, Inc., Nov. 20, 2001.

[130] California Energy Commission Staff Report Otay Mesa Generating Project May 2000, p. 367

[131]Comments on EPA's Proposed Regulation for Cooling Water Intake Structures, Riverkeeper *et.al.*, Nov. 9, 2000. p .21.

[132]*Comments on the EPA's Proposed Regulation on Cooling Water Intake Structures for New Facilities*, prepared by Bill Dougherty, Ph.D., *et al.*, Tellus Institute, November 8, p. 18 .

acceptance and less permitting obstacles. Smoother permitting means a plant can be on-line months earlier, earning back the money spent on dry-cooling. For example, the 480 MW dry-cooled El Dorado Energy Plant build in Nevada by Enron broke ground in 1998 and was online in 1999.

What are the drawbacks to dry-cooling?

There are very few drawbacks to dry-cooling. The cooling units require more land than cooling towers as they to not stick up like factory smokes stacks. There is an incremental efficiency reduction at high ambient temperatures and low ambient humidity conditions compared to wet-cooling. Depending on conditions, this is expected to be no more that 2% on an annual average. When permitting the Otay Mesa Generating Plant, California Energy Commission staff stated, "Given the vast reduction in plant water requirements, staff deems this an insignificant reduction."[133] At the Athens Generating plant in New York state estimates are between 1.4 and 1.9% efficiency loss.[134] Dry-cooling also requires larger up-front capital costs than wet-cooling although these costs are offset over time by the capital and the operating and maintenance costs of wet-cooling auxiliary systems, cost reductions resulting from quicker permitting, and the use of lower cost, non-waterfront property. The destruction of San Diego Bay natural resources also constitutes a "cost" to the region and the environment that has never been recognized and amounts to a subsidy of power generation by the natural environment. If there were true-cost accounting of impacts to water quality, wet-cooling would prove to be the most expensive cooling options by a wide margin.

C. Dry-cooling Case Studies

Dry-cooling is increasing in use

San Diego is not the only location where the conflict is growing over the use of native surface waters for cooling power plants. The use of dry-cooling in power plant applications is widespread and on the increase. There are over 600 dry-cooled electric power plants world-wide and there are 50 dry-cooled power plants in the United States. These plants are of a variety of sizes, types, and located in a variety of climates. Although dry-cooling (like all cooling) can be most effective in colder climates, dry-cooling is used effectively in very warm climates such as Mexico, Nevada, and Saudi Arabia, as well as Southern California. The Public Utilities Commission recently approved the construction of the Otay Mesa Generating project, a 510 MW combined cycle power plant that uses dry-cooling. The world's largest dry-cooled plant is the 4,000 MW Matimba plant in South Africa.[135] Twenty-seven percent of new capacity

[133]CEC staff report, p. 367.
[134]Judge's brief, Case 97-F-1563, pp. 228-229.
[135]Tellus Report, p. 10.

since 1985 has utilized dry-cooling and 4600 MW of dry-cooled power are currently under construction.[136] Locally, the Border Power Plant Working Group recommends that dry-cooling be mandated in all non-coastal areas.

Case Study in Dry-cooling: PG&E Athens Generating Plant, New York

In a recent and significant victory for ecological protection, a new power plant was sited in Athens, New York, near the Hudson River. It is a combined-cycle power plant that will generate 1080 megawatts of electric power–and is dry-cooled. The entire plant and cooling system occupy a 20 acre site and there are no emissions or plumes associated with the cooling system.[137] Combined-cycle technology plants have an efficiency nearly double that of older power plants and in this case the new plant uses only 0.18 MGD (180,000 gallons a day). This amount is only 2.4% of the water that would be used if the Athens Generating Plant used a state-of-the-art closed-cycle wet-cooling system.[138] This plant will kill on the order of one-thousandth of the number of fish of a comparably sized once-through plant. Instead of being resentful of the requirement to use dry-cooling, the PG&E Director of Public Relations told the Albany newspaper *"We're not challenging any of the conditions. We're going to accept it. Glad to have it."*[139]

Case Study in Dry-cooling: The Samalayuca Plant, Chihuahua, Mexico

This plant has been in operation and using dry-cooling since the mid-1990s. The Comisión Federal de Electricidad (CFE-Mexico's utility monopoly) stated that the CFE considers dry-cooling the state-of-the-art cooling system for new power plants, both for performance and environmental reasons.[140]

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[136]Tellus Report, pp. 9-10.
[137]Personal communication, Kristine Schittini, Athens Generating Project, September 25, 2001
[138]Tellus report, p. 14.
[139]*Albany Times-Union*, July 15, 2000 as cited in Riverkeeper *et al.*
[140]Position Paper: Border Power Plant Working Group, p. 7.

Section 4

Recommendations and Rationale for Action

A. Overview of Problems and Solutions

The Problem: Cooling that Kills

The South Bay Power Plant has been severely degrading the San Diego Bay ecosystem with thermal and chemical discharges pollution and killing of plankton, juvenile, larvae, and adult organisms through entrainment and impingement for more than 40 years. These continual impacts have resulted is a degraded marine ecosystem. This degraded condition is now so long-standing that it is considered the "base-line" for South Bay. This grossly inefficient plant is also a source of air pollution and a blight on the community. With increasing evidence of the plant's negative impacts combined with the timing of an NPDES renewal and 303(d) update, **now** is the time to address the plant's chronic impacts.

The Solutions:

1. Build a State of the Art Power Plant to Replace the SBPP

The SBPP must be replaced as soon as possible with a more efficient, dry-cooled plant and there must be aggressive commitments to conservation and clean, renewable energy sources. A dry-cooled plant will not need to use Bay water for cooling. This will result in less air and water emissions and use of less hazardous materials in the region. Officials should establish an enforceable time line to phase out the South Bay plant.

2. Provide Comprehensive and Meaningful Regulation of the Existing Power Plant

The SBPP NPDES permit is up for renewal in December for another five years. In the near-term, the Regional Board must require new, more protective requirements for the discharge. The renewal should include a condition that any replacement plant should not use Bay water for cooling, that impacts from current practices should be fully mitigated, and that the Bay should be restored. The monitoring regime for the new permit should reflect current discharges to the Bay and be designed to fully assess impacts on beneficial uses.

3. Recognize the Impacts of the SBPP on South San Diego Bay

The marine life of South Bay is heavily impacted by the power plant discharge and cooling process. South San Diego Bay should be added to the 303(d) list of "impaired" waterbodies so that it receives priority action for protection.

B. Future Plans for the SBPP

Within the next five year permit period (December 14, 2001 through December 14, 2006), options for the SBPP include:

- Continued operation of the existing power plant;
- Replacement of the existing plant with a new plant; or,
- Cease operations of the plant completely.

Increasing evidence suggests that the power plant will be replaced and this could happen soon. Documents from the City of Chula Vista, San Diego Unified Port District, Duke Energy, and advocates wishing to form a public utility district show it is the strong intention that the SBPP be torn down and replaced. Some of this evidence includes:

1. Closing Sales Documents (1998)

"Buyer proposes that the closure and decommissioning of the Plant would serve the public interest by mitigating air, water and other environmental, health and safety, and community impacts associated with the Plant." [141]

2. Cooperative Agreement Port and Duke (1998)

"*...Duke shall use commercially reasonable efforts to develop, finance, construct and place into commercial operation a new generation plant replacing the South Bay Power Plant..."* [142]

3. Resolution of the Directors of Duke Capital Corporation (1998)

"Duke South Bay will agree to use its commercially reasonable efforts to develop a new generating facility to replace the capacity of the South Bay Plant pursuant to the terms of the Cooperation Agreement.." and " Duke South Bay anticipates making ceratin capital expenditures at the South Bay Plant.....in order...to meet more stringent environmental criteria and anticipates expending certain of its own funds in order to decommission the South Bay Plant at the end of the Lease." [143]

[141]SDG&E South Bay Execution Closing Documents, December 11, 1998, p. 2.

[142]Cooperation Agreement between San Diego Unified Port District and Duke Energy South Bay, LLC, Dated as of December, 11, 1998, Article 7.

[143]Resolutions of the Directors of Duke Capital Corporation, Effective December 9, 1998.

4. State Lands Commission

A January 9, 1999 staff report to the State Lands Commission outlined the Port's rationale for purchasing the power plant. *"The Port's purchase of the property would be with the intent of decommissioning and demolishing the plant for the betterment of the San Diego region and to make these bayfront lands available for Public Trust purposes..."* [144]

5. San Diego Unified Port District

The December 3, 1998 Port District staff report states "*The Port of San Diego recognized that it would be in the baywide region's best interest to purchase the plant as the means to accelerate the closure, decommissioning and/or relocation of the plant."* [145] If a relocation or closure of the plant is not possible, the Port made clear that, "*If reasonable commercial efforts fail to identify an acceptable site away from the SBPP site, the Port may permit Duke to construct the RGP at the South Bay site. A modern, more efficient and environmentally sensitive plant could be built on approximately 25 acres..".*[146]

6. San Diego Daily Transcript (1999)

"...Duke Energy Power services to lease and operate the plant for 10 ½ years during which time Duke is required to dismantle the plant and either build a smaller and more environmentally friendly plant on the same site or relocate and build elsewhere." [147]

7. San Diego Union Tribune (2001)

"Duke said efforts to find a new site for a power plant have failed....The company plans to file applications by October to build a new plant on 30 acres at the current site." [148]

The intent is crystal clear. There will be efforts to replace the SBPP and the planning will occur soon.

C. The Rationale for a "Dry-cooled" Replacement Plant

A repower alone, however, is insufficient. We must address the ongoing impacts of the SBPP with the cleanest repower possible and Duke's "Moss Landing" approach is not an option. Although Duke has expanded the power plant in Moss Landing, this was done without reducing or eliminating the heated water discharge. Such action will be vigorously opposed in San Diego. In the case of Moss Landing, Duke "mitigated" the biological impacts of pumping 1.2

[144]Staff report to the State Lands Commission, January 29, 1999, p. 2.
[145]Staff report to San Diego Unified Port District December 3, 1998, p. 4.
[146]Staff report to San Diego Unified Port District, December 3, 1998, p. 14.
[147]"Next Level in Win-Win Deal May Be Hard To Reach," *San Diego Daily Transcript*, August 19, 1999.
[148]"Port's South Bay deal with Duke draws fire," *San Diego Union Tribune*, May 2, 2001.

billion gallons a day of seawater by paying $12 million to five environmental groups.[149] Fortunately, Voices of the Wetlands and Earthjustice Legal Defense Fund, opposed the impacts and has filed a lawsuit in an attempt to overturn the State's permit renewal.[150]

A New Plant with Dry-cooling is the Only Acceptable Replacement Option to Protect Environment, Public Health, and Community Interests

A feasible and reasonable alternative to the use of once-through cooling in a old, inefficient power plant exists and is readily available. Dry-cooling of a new, more efficient power plant would result in reduction in water use by over 99% over once-through wet-cooling and over 95% over closed-cycle cooling. This would provide tremendous environmental benefits because water use could be met with a non-Bay water source. Dry-cooling also uses no chlorine or chlorine products, thus reducing the impacts on the bay and eliminating the use of hazardous materials and the impacts related to the production, transportation, and storage of this highly toxic material.

Air emissions could also be significantly reduced. Currently, the SBPP emits an unacceptable 3.1 tons (6,200 pounds) a day of NO_x. and 0.8 tons (1,600 lbs.) of PM_{10} at peak generation burning natural gas.[151] Emissions from a new, more efficient power plant with dry-cooling would dramatically lower this total. The Otay Mesa Generating Project provides an example of how a repowered SBPP could result in reduced air emissions. In contrast to the gross emissions from the SBPP, the new Otay Mesa Generating Station is anticipated to produce 716 pounds of NO_x and 916.8 pounds of PM_{10} a day as a worst-case emissions for its 510 MW generating capacity.[152] It is important to note that many factors complicate a comparison of one plant's emissions to another, such as the size of a plant, the effectiveness of control technologies, and other factors. However, a comparison between the peak emissions in 2001 at the SBPP power plant and the predicted worst-case emissions from the OMGP can provide an estimate of how much less pollution a repowered SBPP might emit. The predicted worst-case emissions of NO_x and PM_{10} from OMGP would be 83 percent and 17 percent lower per megawatt of energy produced than peak day emissions at the SBPP.

Moreover, the illusive power crisis has precipitated an unprecedented rush to construct large-scale power and peaker power plants in the region. These are targeted for areas on both sides of the U.S./Mexico border and will add tons of dangerous air pollutants to an overburdened air basin where residents are already exposed to levels of air pollution considered hazardous to human health. Plants in Mexico are under construction without the mitigation off-sets required in the U.S. This allows a U.S. corporation to avoid $50-55 million of mitigation costs and relies on residents of the region to subsidize corporate profits with their

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[149] "Cutting a deal on the environment. Activists accused of favoring cash over mission at Moss Landing," San Francisco Chronicle, June 3, 2001.

[150] *Environmental group sues to stop Monterey power plant's expansion*, Sacramento Bee, July 28, 2001.

[151] *Op. cit.*, Steven Moore, Testimony, April 25, 2001, p. 8.

[152] Final Staff Assessment, Otay Mesa Generating Project, Application for Certification (99-AFC-5), p. 25.

lungs.[153] As cited above, a recent examination of the siting of 18 new power plants in California revealed that the majority of these (over 80%) are being built in poor communities of color, thus ensuring they would bear the worst of the impacts.[154] The South County/Tijuana air basin is already heavily impacted and new power plants will make the situation worse. Any plants operating in this region must be as clean as possible and impacts to air quality fully mitigated.

The SBPP is also the worst urban blight in the South County. Its antiquated industrial revolution appearance frustrates economic and tourism development for Chula Vista and Imperial Beach as well as South San Diego. A new plant could be moved off the bayfront and have a lower, less industrial profile.

We are in a new century and a new era in many ways. That we would greatly benefit, and profit, by developing a sustainable, local energy source is clear. It is also clear that there are a number of options. Replacement of the power generation of the SBPP could involve a new, more efficient plant at this location or another site. It could involve aggressive development of conservation, solar and renewal sources in the region to off-set a portion of the power needs. The replacement could be owned and operated for a public utility district so that the public would have a meaningful voice in how power is generated. **All of the options that reduce the air, water, and negative economic development impacts of the current plant and should be evaluated and pursued soon.**

Efficiency and Economics

Simply put, the current SBPP is obsolete and extremely inefficient which necessarily makes the plant uneconomical. The natural gas supply constraints in San Diego strengthen the case for rapid repowering of the SBPP given that a more efficient plant would yield the same electricity and use less fuel. While we do not at present have information about how much gas a repowered SBPP would require, an indication of those requirements is given by the gas needs of the Otay Mesa Generating Project (OMGP). The OMGP represents a state-of-the-art efficient combined-cycle power plant using dry-cooling. A comparison of the two plants is provided on the chart below. Given the scarcity of natural gas supplies in San Diego, and the limited natural gas supplies worldwide it is important to use natural gas in the most efficient way possible. Further, fuel accounts for over two-thirds of the cost of operating a fossil-fuel power plant.[155] A replaced SBPP is likely to use 25-35 percent less natural gas per megawatt of energy produced than the current plant.

The construction of a new power plant is good for the economy and job creation too. The Athens Plant highlighted in the case studies above will provide construction jobs for three years and use 600 workers for the $300 million project.[156]

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[153]Position Paper: Border Power Plant Working Group, page 8.
[154]Power Against the People? Estrada ECOonsulting
[155]California Energy Commission staff report, May 2000, Application 99-AFC-5, p. 366.
[156]Email from Kristine Schittini, Athens Generating Project, November 6, 2001.

Comparison of Existing Plant with a New, Dry-cooled Power Plant

Impacts	Current SBPP with once-through cooling using San Diego Bay water (737 MW)	New, combined- cycle dry-cooled plant
Killing of Early Life Stages of Organisms	Larvae and eggs of an estimated 8 million goby-type fishes, 240,000 anchovies, and 42,000 topsmelt in one year. Impacts to microscopic life forms are not quantified but expected to be significant.	None
Trapping and Killing of Fishes and Large Invertebrates	Gobies, anchovies, topsmelt killed in the power plant cooling process. One year estimates found that 28,174 individual fish were killed by the plant.	None
Impacts on Clams, Mussels and Other Marine Life	Toxic levels of heat in discharge water for bottom dwelling species. Artificially accelerates growth rate and reduces life span and reproductive abundance in clams.	None
Impacts on Bay Plants	Reduces Chlorophyll a by 88 % in plankton which is the basis of photosynthesis. Power plant discharge increase solids in the water and reduces amount of light necessary for eelgrass habitat in South Bay.	None
Fisheries Nursery Area	SSDB is a critical remaining nursery area of the Bay. The Plant kills many of the early life stages of fishes and other marine life.	None
Halibut	Water is too hot for juvenile halibut and other species. Juvenile halibut tend to be found where oxygen concentration is higher and the chlorinated, heated discharge reduces the amount of oxygen in South Bay water.	None
Species Diversity	South Bay areas dominated by heat-tolerant species like round stingray which are voracious predators of benthic species.	None
Chlorine Use	Up to 89,000 gallons used a year. Toxic to marine life. 6,000 gallons stored on site at a time.	None
Water Discharge to Bay	601 million gallons a day	None
Fuel Use	Oil or Natural Gas	60% less natural gas per MW
Air emissions	6,200 lbs/day NO_x 1,600 lbs/day PM_{10}	**716 lbs/day NO_x** (83% less per MW) **916.8 lbs/day PM_{10}** (17% less per MW)

Legal Implications of Replacing Power Plants

Technology Forcing

Recognizing the potential and need for more protective technologies–particularly in light of past regulatory inadequacies and increasing pressure on our environment–many environmental statues are technology forcing. This is the reason that permits, for example, must be renewed regularly, to adapt to changing circumstances to protect our environment and human health. Highlighting this is the fact that new discharges are now prohibited that exceed 4°F above the natural temperature of the receiving water. The record of the SBPP is far worse than that, yet the SBPP continues to degrade the environment and Duke is requesting to perpetuate this situation into the foreseeable future.

In fact, it is important to recognize that 'NPDES' stands for National Pollutant Discharge ***Elimination*** System, as elimination of water pollution was the stated goal of the federal Clean Water Act. Too often, this concept gets lost and interpretations in the law seem to confuse elimination with continuation of discharges. While it is understandable that time is needed in adjusting to more stringent standards, thirty years is hardly an appropriate acclimation period. We are currently 20 years behind Congress' goal in enacting the CWA to achieve fishable, swimmable water by 1983. Unfortunately, instead of moving in that direction, the original goal often gets lost in the face of cheaper, more convenient solutions. **We must now work toward reaching the original promise of the Clean Water Act.**

Repower/Replace = New Plant Requirements

Today a generating station like the South Bay Power Plant, which uses large volumes of sea water for cooling, would never be permitted to operate in the shallow, enclosed, marine environment of south San Diego Bay. Assuming that a new plant is to be constructed, a major issue is what legal designation will the new plant be given and the subsequent level of discharge limitations under which that plant will be operating.

The California Thermal Plan, adopted by the State Board, was created with the objective of controlling thermal pollution and enhancing water quality in California.[157] It applies to thermal discharges statewide, but has not been updated since 1975. Under the Thermal Plan, a *"new discharge"* is defined as: *any discharge (a) which is not presently taking place unless waste discharge requirements have been established and construction as defined in Paragraph 10 [definition of "existing discharge"] has commenced prior to adoption of this plan or (b) which is presently taking place and for which a material change is proposed but no construction as defined in Paragraph 10 has commenced prior to adoption of this plan.*

A "new discharger" is subject to (1) more stringent new source performance standards, resulting in less thermal pollution to the Bay and (2) the California Environmental Quality Act

[157] *Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California*, State Water Resources Control Board, adopted 1975.

(CEQA) [158] becoming a part of the Regional Board's decision making process in issuing a new permit. However, if a reconstructed plant is judged to be an existing discharge rather than a new discharge, it can operate under the standards set for the previous plant, which are much less stringent[159] and devastation to the Bay will continue far into the future, in violation of the intent of the Thermal Plan and the Clean Water Act.

Legal Interpretation of the "new discharge" issue

The State Board has issued two legal memoranda clarifying the designations given to completely reconstructed power plants. The interpretation of "new" discharges in these two memos is completely contradictory. Reconciling the memos is impossible. Although the State Board dismisses the inconsistency, claiming the first memo was based on incorrect assumptions of fact, the only feasible explanation is the perceived power shortage, resulting sudden demand for power, and intense political pressure around the time the second memo was drafted. Anyone living in San Diego in Spring of 2001 remembers the intense political pressure that was occurring during the perceived power crunch. Governor Davis essentially instructed agencies to soften regulation by issuing Executive Order D-22-01, in order to encourage a higher rate of power production. The second memo's appearance only two months after issuance of the EO is meaningful.

As stated in a State Board legal memo dated March 24, 1999, to be *"consistent with the intent of the original thermal policy, . . . if a new power plant is built, the project proponents will have the opportunity to design the plant to meet the more stringent thermal limits for a new discharge."* [160] Clearly then, a reconstructed power plant should have to meet more stringent discharge limits. The policy behind the first memo was based on a reconstructed power plant's ability to update cooling technology and decrease thermal discharges. More specifically, the rationale behind the memo dated March 24, 1999 is given:

> *"Existing thermal discharges were grandfathered-in in the original thermal policy for two reasons. First, it was felt that the investment that would be needed to upgrade the existing facilities to meet more stringent thermal limitations might not be justified, given their age. Second, the turbines, condensers, and cooling systems in these facilities were designed for a particular design temperature. . . .* ***New facilities, on the other hand, could be built with a different condenser design that could enable these facilities to meet the thermal limitations for a new discharge.****"* [161] (Emphasis added)

[158] *Ibid.. See also* 40 C.F.R. § 122.29(d)(4).
[159] Correspondence between David Maul and Craig M. Wilson, Nov. 3, 2000, p. 5.
[160] *Ibid.*, March 24, 1999, p. 7.
[161] Legal Memorandum issued by Craig M. Wilson dated March 24, 1999, p. 7.

It is clear that the goal of the Thermal Plan was not to support the status quo but rather to promote the incorporation of efficiency into rebuilding while minimizing the aggregate impact on the environment.

A complete shift of position was seen in the second memo issued by the State Board on April 4, 2001.[162] There, the earlier memo is dismissed, and an entirely different claim is made that reconstructed power plants are *"existing sources"* if their discharge experiences *"no material change."* In this memo, material change was read very narrowly, allowing reconstructed power plants to easily surpass the *"new discharge"* designation, thus eliminating their duty to update their cooling structures. The State Board stated that they based their change in position on incorrect assumptions of fact.[163] However, considering the sequence of events, it seems clear that the shift in position had more to do with making power generation more convenient in order to fulfill increased demand and comply with Executive Order D-22-01 than to rectify incorrect assumptions of fact.

Consequently, the validity of the second memo and stance on the status of reconstructed plants, must be seriously questioned. Reconstructed power plants should be considered "new dischargers" and subject to more stringent discharge limitations. This belief is further bolstered if and when the State Board properly lists South San Diego Bay as an impaired waterbody under section 303(d) for the impacts to beneficial uses highlighted above. Once listed, the Regional Board must implement a TMDL for the Bay, which will necessitate much more stringent requirements for the SBPP.

D. Rationale for a Strengthened Discharge Permit for the SBPP and 303(d) Listing of South San Diego Bay as an impaired waterbody

Fundamental Flaw in Regulation of the discharges of the SBPP must be Remedied

The California Thermal Plan requires protection of beneficial uses in enclosed bays. Already in 1967, two years after it began operation, the plant was considered by the U.S. Department of the Interior to be one of two sources of pollution in the South Bay.[164] Yet, the Regional Board has continually made the finding that thermal discharges have not impacted beneficial uses in the Bay, which include habitat for many species of wildlife. One of the reasons for this finding is that the discharge zone of the SBPP has historically been considered

[162] Legal Memorandum issued by Craig M. Wilson dated April 4, 2001.

[163] *Ibid.*, p. 83, footnote 1.

[164] Parrish and Mackenthum. 1968. *San Diego Bay. An Evaluation of the Benthic Environment. October 1967.* Biology and Chemistry Section, Technical Advisory & Investigations Branch, Federal Water Pollution Control Administration, U. S. Department of Interior. p. 21, iv

part of the plant and the Bay (meaning the beneficial uses did not have to be fully protected or considered).

There is a bitter irony here. While, in the past, the Bay has been considered part of the power plant, the reverse is actually the case. In most cases, a waste stream created by a discharger (and separate from the natural waterway) is discharged into a waterbody. The regulatory structure is designed to minimize or eliminate the impacts of this added waste stream on the receiver waterway. However, in this case, the power plant essentially **diverts the bay into the plant**, adds chemicals **for the purpose of killing marine life**, adds waste heat to the bay water in the plant at a level high enough to be toxic to marine life, then returns this heavily altered and degraded water to the Bay. In this case, there is no denying that the chlorine that the power plant adds to the Bay water causes ecological damage–**it is added for that very reason.** This fundamental perception of how the Bay water is damaged is missing from the permitting and regulatory process. It also fails to limit the number of organisms destroyed through impingement or entrainment.

Simply put, the Regional Board can no longer make a finding that there are no significant impacts on beneficial uses as a result of the power plant discharge. In fact, beneficial uses are, and will continue to be, significantly impacted by the elevated temperature discharges and chlorination of bay water by the South Bay Power Plant.

Proposed Permit Monitoring Regime Does Not Assess Impacts or Require Mitigation for Damage

The proposed NPDES permit renewal for the SBPP falls far short of what is needed to comply with permitting requirements. Several important constituents and impacts are not monitored for. Others may be monitored for but have no limits specified and so are unenforceable. For example, there are no receiving water limitations for dissolved oxygen (DO) or temperature in the current permit. The discharge water is not monitored for DO at all. Storm water discharges are not monitored for toxicity. There is not regular monitoring for the metals that are known to exist in the discharge. Chlorination of discharge water is done daily but only monitored every two weeks.

Temperature is also not adequately assessed or limited. Even though, between 1974 and 2000, average discharge temperatures have risen over 10°F in both summer and winter, the heat limit is specified as delta temperature (change between intake and discharge temperatures) but there is no maximum temperature that the discharge water can exceed. Permitted increases in temperature between intake water and water discharged from the SBPP have risen from 12.5°F to 15°F during the time the power plant has operated. Since Duke's request in June, 2001 for an even higher limit (increase to 23°F which was later withdrawn), this issue has become even more urgent. It is clear that the potential exists for discharge temperatures as high as 107° or higher with even more damaging impacts to the bay. A maximum limit, in addition to a delta change limit, must be included in the permit.

Another significant issue related to regulating the power plant relates to where discharges occur, are monitored, and where compliance is assessed. Today, the actual monitoring and compliance points are located far from the actual point of discharge. All constituents monitored in the discharge, except temperature, are monitored about 100 feet from the actual point of discharge. Temperature compliance is assessed 300 yards from the actual point of discharge. One serious problem is this practice does not assess the actual conditions of the discharge and it allows a large dilution of the impacts before compliance is determined. This equates with a de-facto mixing zone for the power plant. While the law allows for mixing zones, certain demonstrations must be made by the discharger before permission for a mixing zone is granted. No such zone has been formally granted by the Regional Board. The historic method of regulating the plant and assessing compliance is still the basis of the new permit and is grossly outdated. There is a critical need to revise and update the monitoring regime and monitoring locations in this next permit.

Storm Water Requirements need to be strengthened and updated in the permit

When the Regional Board renewed the NPDES permit for the commercial shipyards on San Diego Bay in 1997, stronger storm water requirements than required in the General Industrial Storm water permit were added to the General Waste Discharge Requirements for Shipyards. These included diversion of 1/4 inch storm water from high risk areas and toxicity testing of storm water.[165] Similar requirements were previously added in the Commercial Boatyard permit. The SBPP is also a large industrial facility on San Diego Bay and should have the same strengthened permit requirements for monitoring storm water in its renewed permit.

Additional Regulatory Requirements

The SBPP has diverted metal cleaning wastes and low volume wastes to the Chula Vista sewer system. Because of this, they have requested that their current monitoring program be discontinued. However, they have stated in their application for permit renewal that some chemicals continue to be discharged due to the erosion of metal surfaces. The chemicals mentioned include: barium, chromium, copper, lead, nickel, and zinc.[166] SBPP has requested that semiannual monitoring continue to monitor this erosion effect. Semiannual monitoring is not enough. In Appendix H, Table 2C of the SBPP Application for Permit Renewal, chemicals that have been detected in SBPP's effluent are listed. All of the above chemicals, with the exception of zinc, have an effluent value that is greater than the influent value. This is cause for

[165]Waste Discharge Requirements for Discharges from Ship Construction, modification, repair, and maintenance Facilities and Activities located in the San Diego Region. Order 97-36, pp. 14-15

[166]SBPP Application for Permit Renewal, Appendix F, p. 5.

concern. Monthly monitoring is needed, with a Pollution Minimization Program implemented, if appropriate.

Other chemicals must also be included in permitting and monitoring program. Duke lists the following potential chemicals in the discharge in the permit application:

- Rhodamine WT liquid
- Nalco 8322 corrosion inhibitor
- Spectrus NX1103 - for microbial control

In addition, a review of chemicals listed in Duke's complete chemical inventories reported to the County Hazardous Materials Disclosure database should be analyzed for inclusion. Further, halomethanes are a break-down product of chlorine use. Other dischargers that chlorinate, such as Sea World, are required to monitor for these products[167] but the SBPP is not.

South San Diego Bay should be Listed on the 303(d) List

South San Diego Bay is a shallow, sensitive marine environment and critical fisheries nursery area, highly vulnerable to heat, chemicals, and other pollution. Use of once-though water cooling has had a devastating impact on this ecosystem and is causing significant impact to marine life in South San Diego Bay every day. Depending on the tides, the power plant uses up to 20% of water in South Bay every day for cooling and significant multiple recirculation occurs.

This use of bay water severely impacts the marine life (beneficial uses) in South San Diego Bay in multiple ways. The power plant cooling system kills early life stages of marine plants and animals and microscopic organisms through entrainment into the plant. The cooling process heats the water to temperatures that can reach over 100°F, a lethal temperature for fishes, and other marine life. Heated water has been found to artificially accelerate growth rates of some species. These same species produced fewer young and had shortened life-spans. The higher water temperature also decreases the amount of dissolved oxygen in the water and, at the same time, increases the metabolic rate of animals which increases their oxygen demand. The high water temperatures and reduced oxygen in the water may prevent juvenile halibut from settling in South Bay, one of the important, remaining nursery areas.

The SBPP also discharges dead plants, fishes, shellfish and other organisms back into the Bay; the decay of these plants and animals further reduces oxygen levels. The cooling system kills larger fish and invertebrates by trapping them on the intake rack and screens. Eelgrass may be negatively impacted by the additional turbidity and suspended solids that the plant causes in the discharge area.

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[167] Order No. 2000-25,NPDES Permit No. CA 0107336, Waste Discharge Requirements for Sea World San Diego, San Diego County, Discharge to Mission Bay, April 12, 2000.

The use of chlorine is also a severe impact. Chlorine is highly toxic to marine life and large volumes are used to prevent marine life from attaching to pipes in the cooling water system. Heavy use of chlorine presents elevated risks of fish kills if chlorination valves get stuck open. Chlorine by-products are also of serious concern and are unmonitored and unassessed.

Compromised Data

These impacts, over the period of 40 years, are cumulatively significant. The status of the science on the impacts, however, is highly suspect for two reasons. First, virtually all of the data collected on the impacts of the plant use a baseline of ecological health during time periods when the plant was in operation. This skews the data to protect a status quo that is already damaged by plant operations. Second, virtually all of the studies were funded in whole or in-part by the power plant operators. Scientific assessment funded by a discharger with a very significant interest in the outcome renders the studies and the conclusions, highly suspect. Independent studies based on the baseline of ecological conditions prior to operation of the cooling system must be conducted before we know the full impact of the cooling water discharges on San Diego Bay.

All of these elements combine to support the need for a stronger discharge permit and for listing of South San Diego Bay as impaired for heat, chlorine, and copper.

E. Agency Recommendations

The member organizations of the San Diego Bay Council, representing 22,000 San Diegans, are committed to act through community involvement, regulatory participation, and legal action, to ensure that the South Bay Power Plant is torn down and its damaging impacts to sensitive South San Diego Bay are ended. To this end, we make the following recommendations to the agencies involved with siting and permitting power plants.

State Water Resources Control Board

- The State Board should ensure that the updated Thermal Plan provides more protective requirements for Thermal discharges into state waters. The update should re-designate San Diego Bay as an estuary and/or strengthen the protections in the Thermal Plan for enclosed bays. The new Thermal Plan should require dry-cooling for all coastal power plants. It should specify that all repowered plants are to be considered new discharges for purposes of permitting.

- The State Board should add the waters of South San Diego Bay to the 303 (d) list as impaired for heat, chlorine, and copper.

Regional Water Quality Control Board

- Regional Board should specifically address requirements on any replacement plant for the SBPP and make clear the intent of the Board for any future proposal. This could be accomplished through a condition in the new NPDES permit or a resolution requiring any reconstruction/repower during this permit duration to carry a "new discharge" designation and, thus, subject to much more stringent requirements.
- Regional Board should strengthen the NPDES permit, increase monitoring, and require mitigation for damage caused by the operation of the SBPP in order to ensure protection of beneficial uses in San Diego Bay. The new permit should move closer to the elimination of water quality impacts from the power plant discharges as soon as possible. Essential changes include: establish limits and monitoring requirements for dissolved oxygen and all constituents present in the discharge such as metals and chlorine by-products; relocation of the compliance point to the real point of discharge (i.e. end of the pipe); set maximum temperature limits for the discharge; establish impingement and entrainment limits; establish sediment monitoring; and increase frequency of chlorine monitoring.
- Regional Board should ensure that storm water requirements should be incorporated into the renewed permit and strengthened to include, at a minimum, acute toxicity and diversion of storm water from high risk areas.

San Diego Unified Port District

If the Port has the ability to renegotiate the lease for the power plant, the Port should ensure that any operator is held to hard and fast deadlines for removal of the SBPP and a requirement for any new plant on Port District tidelands to utilize dry-cooling. The Port should maintain some measure of public control over operation of the plant.

California Energy Commission

CEC should require all new and repowered plants to use dry-cooling as the system that impacts air and water quality the least and reduces use of hazardous materials.

National Marine Fisheries Service

NMFS should determine all actions that should be taken to rehabilitate the South Bay habitat for sea turtles once the discharge from the SBPP is removed. This should include a plan for returning the South Bay to more natural conditions and restoration of eelgrass beds for foraging.

San Diego Regional Energy Office

The SDREO should recommend an aggressive Regional Energy Strategy that aggressively pursues conservation, efficiency, and clean renewable energy to the maximum extent possible for the San Diego/Tijuana region.

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Environmental Health Coalition - EHC is dedicated to achieving environmental and social justice. We believe that justice is accomplished by empowered communities acting together to make social change. We organize and advocate to protect public health and the environment threatened by toxic pollution. EHC supports broad efforts that create a just society and which foster a healthy and sustainable quality of life.

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San Diego BayKeeper - The San Diego BayKeeper, a nonprofit membership organization, is dedicated to the principal that protecting California's precious coastal waters is the job of every citizen. San Diego BayKeeper is a member of the national Water Keeper Alliance. Our common purpose is to preserve, enhance and protect the state's marine sanctuaries, coastal estuaries, wetlands and bays from illegal dumping, hazardous spills, toxic discharges and habitat degradation.

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Wildcoast - Wildcoast is a partnership-based inter-national conservation team preserving the endangered marine species and coastal wildlands of the Californias.

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